

THE LICHENS OF MINNESOTA.

By BRUCE FINK.

INTRODUCTION.

BASIS AND AIMS OF THE PRESENT WORK.

The author began his investigation of the lichen flora of Minnesota during the summer of 1896 and finished the work in the field during the summer of 1902. The preparation of the descriptive catalogue offered herewith has been in progress since the latter date. During the course of the field work seven papers were published in the Minnesota Botanical Studies, which are referred to in the present work as the "preliminary reports." Their full titles will be found in the bibliography at the close of the introduction.

The data of distribution as given in the preliminary reports could not be incorporated in full in the catalogue, but in case of species known only from one, two, or three places the specific localities are cited. Local students are referred to the reports mentioned for more complete information. To these reports also, the reader must be referred for matter relating to geographical and ecological distribution until it becomes possible to publish the fuller data on these subjects already brought together.

The aim in the catalogue has been to furnish descriptions and keys adapted to the use not only of specialists but also of younger students. To this end it has been the endeavor to avoid technicality so far as is consistent with clear presentation.

One of the faults of existing descriptions of lichens is their failure to give measurements of the size of thalli. Such measurements can only be approximate, often including neither the smallest nor the largest specimens that actually occur; but even so it is believed that they will greatly aid in the determination of the species, and they are accordingly here supplied. Another error on the part of some authors, found especially in brief descriptions, consists in the arbitrary definition of characters, leading the student to expect a constancy as to size, form, and color which does not exist in lichens. The attempt has been made in the present descriptions to state these variations as accurately as possible. While the catalogue treats of the lichens of

a single State, lichen species in general are so widely distributed that the descriptions and figures will, it is hoped, prove helpful in the determination of lichens throughout North America, and especially throughout the northern United States and British America.

As the method of determining the application of generic names of lichens is still in controversy, it has seemed best to use them in the traditional sense, stating the types of the genera according to the "first species" rule. In instances in which the type falls without the genus as at present understood, statement is made to that effect. It is manifest that, until there is general agreement as to a method of typifying genera and until all the nominal lichen genera have been typified according to this method, anything done toward a revision of the generic names would as likely as not have to be done over. Likewise, until lichen species have been typified as exhaustively as possible, any extended synonymy of them can be of little value. Consequently, nothing has been attempted in the way of synonymy of the species described, beyond stating, in instances in which a species has been transferred from the genus in which it was first described, the citation for the first combination as well as for the one used herein. The priority of specific names can be settled only by the examination of a large number of type specimens in European herbaria, and as the author has not been able to see these, there is no doubt that at least a small portion of the specific names here used will eventually have to give way to others.

Until we know more regarding the phylogeny of lichens and the structure of sexual reproductive tracts, anything approaching finality in their taxonomy is scarcely possible. The writer has been influenced in classification by a number of authors, especially by A. Zahlbruckner in Engler and Prantl, but holds himself alone responsible for the arrangement of families and genera used. In fixing upon the sequence of genera and of closely related families, both spore characters and vegetative structure have been taken into account. Doubtless the concurrent resemblance in these two respects is often merely accidental and it does not therefore always imply the close relationship that juxtaposition would indicate. These difficulties arising from this circumstance can only be settled by future investigations of anatomy, reproductive processes, and phylogeny.

It need scarcely be stated that the descriptive catalogue is the main feature of this work and that the preceding chapters, treating very briefly of the origin and nature, the morphology, the reproductive processes, and the uses of lichens, are intended as an aid in using it. It has, therefore, not been thought necessary to add a list of references to this part of the lichen literature.

The writer takes this opportunity to express his thanks to several persons who have aided in the work in various ways. First of all, he

is under obligation to Prof. Conway MacMillan for placing at his disposal facilities which made possible the work of the survey and preliminary study as well as the earlier work of preparation. His thanks are also due to the Board of Regents of the University of Minnesota for the privilege of using this material, prepared by himself in large part while a member of the botanical survey of Minnesota for publication elsewhere.

The later work of preparation was done at Washington, where chiefly the library of the United States Department of Agriculture afforded a large amount of literature used in verifying citations to species and in ascertaining the types of the genera. Thanks are due to Mr. Frederick V. Coville for many helpful suggestions regarding the work. The writer wishes especially to express his thanks to Mr. P. L. Ricker for aid in literary work connected with citations. Besides the libraries at Washington, the Lloyd Botanical Library at Cincinnati was much used, and the writer is under special obligations to the owners for access to this library, as he is also to the librarian, Mr. William Holden, for many favors while working there. The writer's private library, the botanical library of the University of Minnesota, and that of the Missouri Botanical Garden were used during the early part of the work of preparation, and rare volumes were borrowed from various other libraries toward the close of the work, until all citations were verified.

Thanks are also due to Dr. E. Wainio, of Helsingfors, Finland; to Dr. A. Zahlbruckner, of Vienna; to L. Scriba, of Höchst a. Main, and to Dr. T. Hedlund, of Upsala, Sweden, for comparing specimens with authentic material and aiding in difficult determinations. Dr. W. G. Farlow, Dr. G. Lindau, of Berlin, and Doctor Zahlbruckner have also aided very kindly in the matter of citations. It is in order also to express appreciation of the services of Mr. C. J. Hibbard, in taking, under the author's direction, the photographs of lichens as they occurred in the field, from which the greater portion of the illustrations are reproduced.

Of the other illustrations thirteen plates and four text figures are reproduced from Schneider's Text-book of General Lichenology, for the privilege of using which thanks are due to Dr. N. L. Britton. Plate 16 is from an electrotype kindly loaned by Mrs. A. M. Smith, editor of the *Bryologist*, in which the plate was originally published. Nine text figures are reproduced by the kind permission of Dr. J. Reinke, of Kiel, Germany, from Pringsheim's *Jahrbücher*, volume 28. Of the remaining figures two are by permission from Sachs's Text-book of Botany, two from Stahl's *Geschlechtliche Fortpflanzung der Collemaceen*, and one partly from De Bary's *Comparative Anatomy* and partly from Tulasne. The sources of the nonoriginal illustrations are indicated under each.

Several students of the writer have aided materially by careful studies, under supervision, of many of the species described herein for details of microscopic structure and in subjecting portions of the manuscript to the test of use before publication. To all these the writer wishes to express his thanks.

Full sets of specimens of the species described herein may be found in the United States National Herbarium, the herbarium of the University of Minnesota, and the writer's private herbarium.

Below is given a list of the works hitherto published containing matter regarding the lichens of Minnesota.

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 - II. Lichens of Minneapolis and Vicinity. Minn. Bot. Stud. **1**: 703-716. My. 1897.
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 - IV. Lichens of the Lake Superior Region. Minn. Bot. Stud. **2**: 217-276. D. 1899.
 - V. Lichens of the Minnesota Valley and Southwestern Minnesota. Minn. Bot. Stud. **2**: 277-329. D. 1899.
 - VI. Lichens of Northwestern Minnesota. Minn. Bot. Stud. **2**: 657-709. My. 1901.
 - VII. Lichens of the Northern Boundary. Minn. Bot. Stud. **2**: 167-236. Jl. 1903. A series of papers containing extended notes on habitat, distribution, and ecology of Minnesota lichens and referred to in this volume as preliminary reports.
- Fink, Bruce. Notes concerning Iowa Lichens. Proc. Iowa Acad. Sci. **5**: 174-188. 1897. Largely a comparison of the lichen floras of parts of Iowa and Minnesota.
- Fink, Bruce. Notes on the Lichen Distribution in the Upper Mississippi Valley. Mem. Torrey Club **6**: 285-307. D. 1899. Names in the list all Minnesota lichens known at the time of publication.
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 - III. Cladonia furcata and Cladonia crispata. The Bryologist **7**: 53-58. Jl. 1904.
 - IV. Cladonia verticillata. The Bryologist **7**: 85-88. N. 1904.
 - V. Cladonia gracilis. The Bryologist **8**: 37-41. My. 1905.
 - VI. Cladonia cariosa. The Bryologist **9**: 21-24. Mr. 1906.
 - VII. Cladonia subcariosa, Cladonia mitrula, and Cladonia leptophylla. The Bryologist **9**: 57-60. Jl. 1906.
 - VIII. Cladonia botrytes, Cladonia caespiticia, and Cladonia delicata. The Bryologist **9**: 89-91. N. 1906.

Fink, Bruce. Further Notes on Cladonias—Continued.

IX. *Cladonia squamosa* and *Cladonia subsquamosa*. The Bryologist 10: 21–23. Mr. 1907.

X. *Cladonia decorticata* and *Cladonia degenerans*. The Bryologist 10: 41–45. My. 1907.

XI. *Cladonia pyxidata* and *Cladonia pityrea*. The Bryologist 10: 57–60. Jl. 1907.

XII. *Cladonia bacillaris*, *Cladonia macilenta*, and *Cladonia didyma*. The Bryologist 10: 77–79. S. 1907.

XIII. *Cladonia cristatella* and *Cladonia coccifera*. The Bryologist 10: 97–100. N. 1907.

XIV. *Cladonia digitata*, *Cladonia deformis*, and *Cladonia bellidiflora*. The Bryologist 11: 21–24. Mr. 1908.

These papers are the outgrowth of work done mainly in Minnesota, afterwards extended to include North American distribution.

Fink, Bruce. Two Centuries of North American Lichenology. Proc. Iowa Acad. Sci. 11: 11–38. 1904. Contains references to work in Minnesota.

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PRELIMINARY ACCOUNT OF LICHENS.

VIEWS AS TO THEIR ORIGIN AND NATURE.

Lichens have been at various times regarded as algæ, fungi, mosses, and liverworts, and Tournefort, in 1694, was the first botanist to classify them as a distinct group of plants. Subsequent study of anatomy and reproductive processes brought Tournefort's view into general favor, and the question of the place of lichens in the plant world was supposed to be settled. For nearly two centuries a literature of lichenology was growing up, based upon the unquestioned assumption that lichens are autonomies. Every botanist who does systematic work on lichens at present, whatever his opinions, must

use this literature, and it is therefore requisite to give some explanation of its leading conceptions and of the terms used.

There are in all lichens, at least at some period of their life, certain cells or chains of cells of a green color, or more rarely of a blue-green, brownish, or reddish color. If green, these cells were called "gonidia" (fig. 1, *a*, p. 9). If blue-green, they were called "gonimia" (fig. 1, *c*). Besides these cells or cell groups or filaments there are the well-known hyphæ of the lichen thallus, which have in the phylogenetic development of lichens very frequently become transformed in part into a parenchymatous structure, the cortex. In extreme instances, the whole hyphal structure has been transformed into cellular structure, while, on the other hand, in many of the lower lichens the cellular structure is entirely absent and the green or blue-green cells and the hyphæ compose the whole vegetative portion of the lichen. It was until recently supposed that the green or blue-green cells arose in the development of each lichen, probably from the hyphæ, and that the relation of the chlorophyllous to the hyphal portion of the thallus was the same as that of the chloroplasts of higher plants to other portions of the plant body. Thus both the green or blue-green cells and the hyphæ or equivalent parenchyma were regarded as integral parts of a single organism. It had long been known, however, that the green or blue-green cells in the lichen thallus are like certain algæ (figs. 1, 2, pp. 9, 10), and De Bary, the first botanist to investigate the resemblance carefully, advanced the suggestion that the alga-like cells of lichens might actually be algæ somewhat modified by peculiar conditions of existence. Schwendener, at first hostile to this suggestion, in 1868 announced his conviction, based upon the examination of lichen thalli, that the lichen is composed of two distinct portions, a fungal and an algal. Later investigations have established beyond doubt the main points of this view and have shown that the algæ in many lichens may be isolated, in which case they behave very much like similar free algæ. Some investigations of the fungal portions of lichens followed, and the conclusion was reached that the lichen could not be regarded as an autonomy at all, but must rather be considered a compound organism composed of a fungus and an alga, the two living together in the relation known as symbiosis.

Symbiosis, however, is of different kinds. It may exist with benefit to both organisms, the relation then constituting mutualism or mutualistic symbiosis; or it may exist with benefit to one of the symbionts and injury to the other, constituting parasitism or antagonistic symbiosis. In the early days of the investigation of symbiosis in lichens it was supposed that the fungus member which produced the fruit was benefited by the association while the alga was injured, the fungus thus being regarded as a parasite and on the alga as its host.

Setting out from this conception of the relationship of the two symbionts, botanists began to classify lichens as fungi.

In other instances of symbiosis than that found in lichens one or each of the symbionts is able to live quite independently of the other. In certain lichens the alga has been isolated from the association and has grown and produced reproductive bodies. Likewise the fungi forming some lichens have been isolated and have produced, in nutritive media, forms resembling the ordinary thalli of the lichen species. However, it may well be doubted whether either the fungal or the algal symbiont ever becomes free in nature and lives during its whole life period outside the symbiotic association. Thus, we seem to have in lichens the highest expression, so far as it is known, of mutualism. The alga does not reproduce in the association, except by fission, but it is protected in such a manner that it can grow where it could not otherwise, and its continued existence, or the succession of individuals rather, is assured. And though the fungal symbiont produces various reproductive bodies, it may well be doubted whether any reproduction other than vegetative often takes place in lichens in a state of nature. Again, it is evident from observation, that many new species of lichens have been evolved from closely related species. Thus the lichen, after all, in many ways appears much like a morphological unit, and J. Reinke has arrived at the conclusion that it must be so regarded, and has succeeded in unsettling to some extent the idea that lichens should be regarded as fungi.

Some botanists still hold that the relationship of the fungus and the alga is antagonistic. Whatever may be the outcome of further study of this question, the conception brought out in the above historical review, which is still held by some botanists, that the fungus and the alga together compose an organism or an association which constitutes the lichen must be abandoned before there can be any clear thinking regarding lichens. The lichen is the fungus of the association. This is true even in the few instances in which the alga determines the form of the thallus.

Certain botanists regard it as a corollary of this conclusion that, from a strictly systematic point of view, lichens should be distributed as fungi and some workers have already taken this position;^a but there are still some lichenists and other botanists who would be pleased with no other statement than that lichens compose a distinct group of plants. In view of the lack of agreement among authorities and for strong practical reasons it is not held advisable to undertake the distribution of lichens as fungi in the present paper.

^aSee Bessey's "A Synopsis of Plant Phyla," University of Nebraska Studies 74:1-99. 1907, and Clements's, "The Genera of Fungi," 1909, briefly reviewed in SCIENCE; n. ser. 30:567, 568. Oct. 22, 1909.

DISPOSITION OF LICHENS ADOPTED IN THIS WORK.

It is here accepted as an established fact that lichens arose through associations of alga and fungus in a symbiotic relationship. Once a lichen was established, it began to vary, so that we now have abundant evidence that many genera and species of lichens belong to the same phylogenetic tree.

The vegetative tract is commonly much reduced in fungi as a result of parasitism or saprophytism, since the food is either prepared by the host plant or found ready made in the substratum. However, in the fungi which have entered into associations with algæ to form lichens, the vegetative tract or thallus has assumed the new function of protecting the algæ so that they can increase in number and perform more effectively their duty in the partnership. In response to this change in function, the highly varied and complex foliose and fruticose thalli of the higher lichens have arisen, in their evolved forms departing widely from the most closely related fungal ancestors.

Add to this the peculiarities of reproduction among lichens, a problem still needing careful study, and we shall have some of the facts which cause many botanists to maintain that lichens, after all, constitute a distinct class of fungi, or perhaps two distinct classes. However, others hold that lichens should no longer be treated separately except for special purposes in much the same way as parasitic fungi or poisonous plants, not necessarily all closely related, are often grouped together. Further phylogenetic studies may lead to the distribution of lichens among fungi, to the exclusion of the class Lichenes. This method would then be used in the general systematic treatment of fungi, though there would still remain students who would treat lichens separately. The present work is the result of many years of study of the lichen flora of a particular region, and therefore a separate treatment is the only method available. Taking into account, then, the unsettled state of opinion regarding the classification of lichens and the purpose of the present treatise, it seems best to follow Engler and Prantl in recognizing the class Lichenes.

THE FUNGAL SYMBIONTS AND THEIR RELATED FUNGI.

In all of the common lichens of temperate regions the fungal symbionts are Ascomycetes. The fungus has become so modified, in many instances, since entering into the symbiotic relationship, that there is little resemblance between it and the ancestral form. There is sufficient likeness, however, to lead to a general conviction that the fungal symbionts have been evolved in part from the Discomycetes and in part from the Pyrenomycetes. Of these two groups such genera as *Peziza*, *Patellaria*, *Hysterographium*, *Melaspileia*, *Phacidium*,

Chaetomium, and Sordaria are among those which may be closely related to the ancestors of the fungal symbionts. Further statements concerning the fungal ancestry will be found in the outline of classification.^a

THE ALGAL SYMBIONTS AND THEIR RELATED ALGÆ.

The algal symbionts are much better understood than the fungal. Indeed, in the descriptions of genera in this volume statements are made regarding the algæ to be found in each genus, and some use is made of these algal types in classification into families and genera.

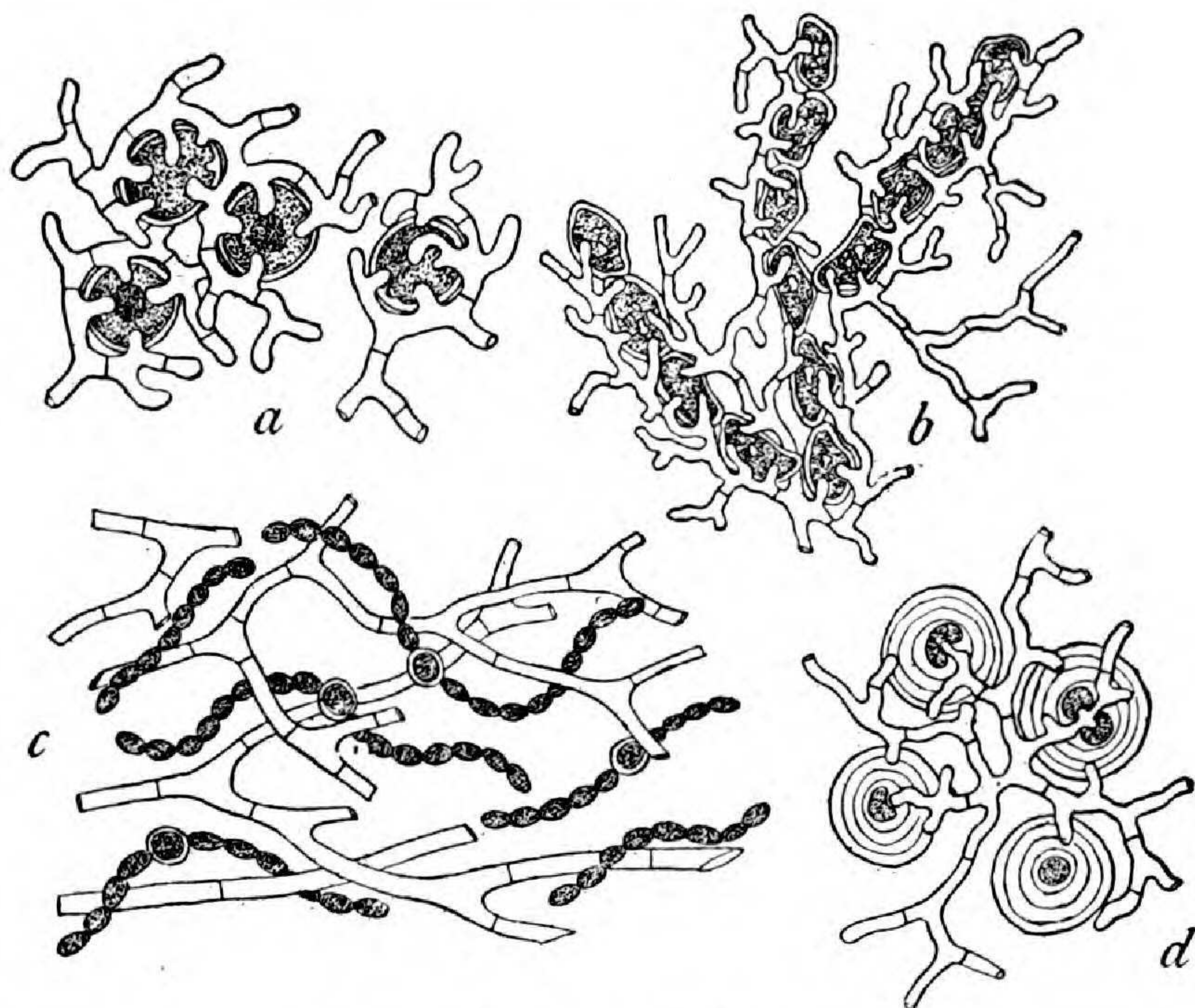


FIG. 1.—Algal types with associated fungal hyphæ. *a*, *Cystococcus*, each cell surrounded by haustoria. *b*, *Chroolepus*, showing a branching chain of cells, surrounded by haustorial hyphæ. *c*, *Nostoc*, showing the algal filaments and the intermingled fungal hyphæ. *d*, *Gloeocapsa*, showing the haustoria and the fungal hyphæ surrounding the algal cells. *a*, Enlarged 750 diameters; *b*, 325 diameters; *c*, 500 diameters; *d*, 650 diameters. From Schneider.

The alga most commonly found in lichen thalli is of the genus *Cystococcus* (fig. 1, *a*), and this genus is closely related to *Pleurococcus* (fig. 2, *d*, p. 10), which itself is supposed to be the algal symbiont of a few common lichens. Sections of lichens of the genera *Collema*, *Synechoblastus*, *Leptogium*, and some others show chains of cells which are so similar to those of free-living species of the algal genus *Nostoc* that we may regard these algal symbionts as certainly belonging to that genus. *Chroolepus* (fig. 1, *b*), an alga which may readily be distinguished from *Pleurococcus*, is the algal symbiont in a considerable portion of the crustose lichens. Other algal symbionts, which will be referred to only rarely in these pages, are *Gloeocapsa*

^a Page 37.

(fig. 1, *d*, p. 9), *Rivularia* (fig. 2, *a*), *Polycoccus* (fig. 2, *b*), *Dactylococcus* (fig. 2, *c*), and *Sirosiphon* (fig. 2, *e*).

GROSS MORPHOLOGY.

Under this head we shall consider only those lichen structures which may be seen readily with the unaided eye or with an ordinary hand lens.

THE THALLUS.

The fundamental part of a lichen is its vegetative tract or thallus. The thallus may be an erect structure, rising from the substratum, a pendulous one hanging downward from it, a conspicuous or inconspicuous flat one closely or loosely attached to the substratum, or

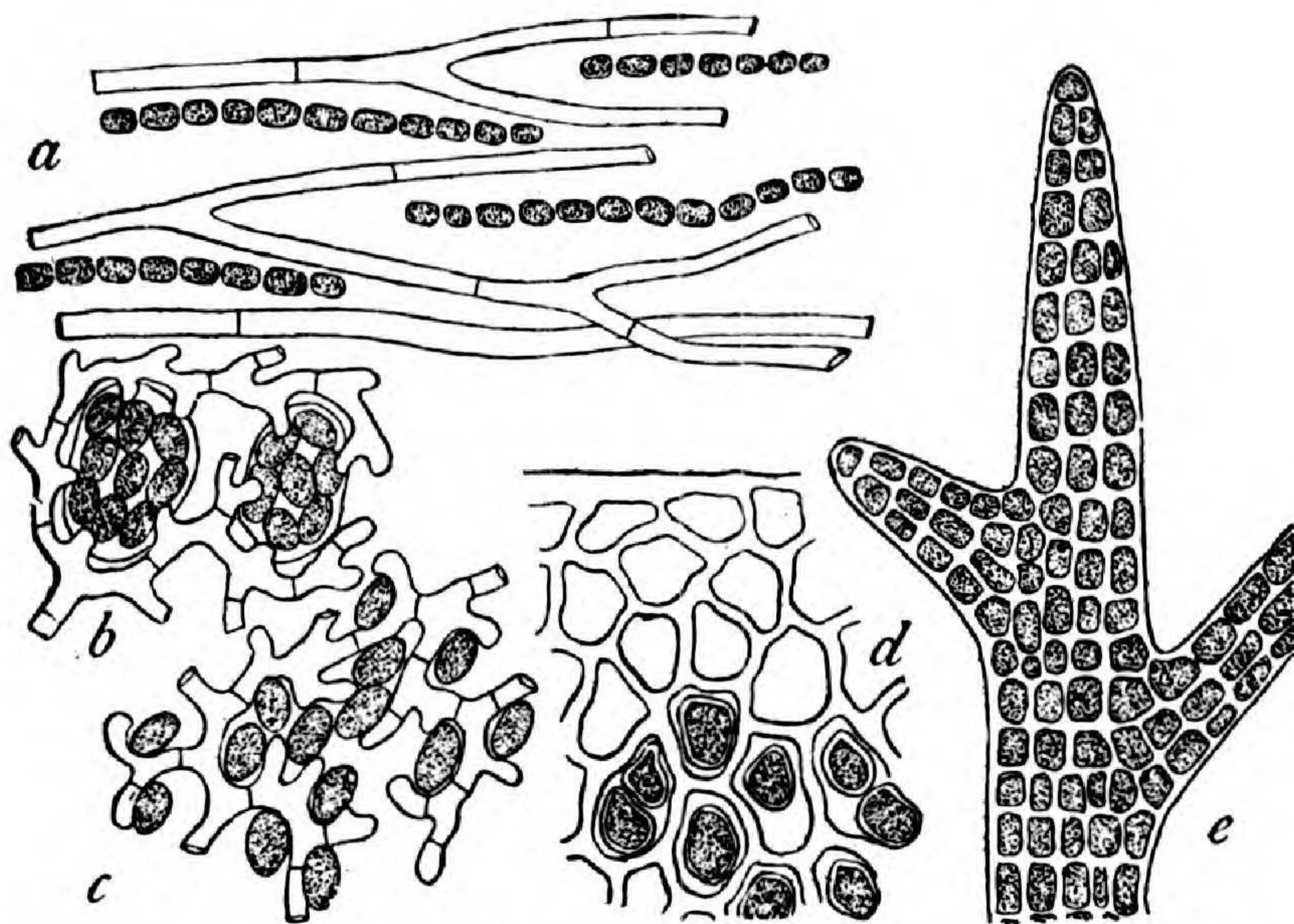


FIG. 2.—Algal types with associated fungal hyphæ. *a*, *Rivularia* with the fungal hyphæ intermingled. *b*, *Polycoccus*: colonies of cells surrounded by hyphæ and haustoria. *c*, *Dactylococcus*: elliptical algal cells and fungal hyphæ. *d*, *Pleurococcus*, the irregular algal cells inclosed in fungal hyphæ. *e*, *Sirosiphon*, a terminal branch not showing the fungal hyphæ. *a*, Much enlarged; *b*, *c*, enlarged 325 diameters; *d*, 450 diameters; *e*, 250 diameters. From Schneider.

an inconspicuous one largely or even wholly embedded in the substratum. Erect and pendulous forms are commonly called fruticose thalli (pl. 43, A, facing p. 210), and the flat or horizontal ones may be either foliose (pl. 28, facing p. 157) or crustose (pl. 8, B, facing p. 100); foliose when somewhat leaf-like and crustose when forming a closely attached crust resting on or within the substratum. Various intermediate conditions between crustose and foliose and between foliose and fruticose types of thalli may be expected in the study of lichen species.

GENERAL FORMS OF THALLI.

Of the foliose forms, many are variously lobed (pl. 30, facing p. 160) and some are quite entire at the margin. In instances where the lobing is evident the lobes may be more or less imbricated. In both lobed and unlobed forms the margin may be wavy or crenate instead of

entire, and it may be either ciliate or devoid of cilia. The most obtrusive differences among the fruticose thalli consist in their being branched or unbranched and, when the former, in the manner of their branching. Secondary differences are found in the character of the surface, particularly in various small outgrowths other than the branches, known as phyllocladia. The crustose thalli appear usually as a more or less conspicuous layer spread over the substratum or sometimes really lying wholly or partly in it and indicated at the surface often only by a change in color. These crustose thalli will be found to be irregular in outline or more or less plainly orbicular and to form a continuous or a more or less broken and scattered stratum (pl. 8, A, facing p. 100). In some species the tendency is toward orbicular forms and in others toward irregularity in form, but in any case the peculiarities of the surface of bark, dead wood, or rock forming the substratum will determine the form of the particular thallus to a large extent.

Lichens are of late evolution, and the forms are still quite plastic. Nevertheless, the forms, sizes, and colors of lichen species are quite as constant as those of many other organisms, whether plant or animal. Indeed, in many lichens the morphological characters, whether gross or minute, are quite as constant as are those of most flowering plants, and it may well be doubted whether even the *Cladonias* are more plastic than the members of the genus *Crataegus*, including our common hawthorns.

SIZES OF THALLI.

In northern Minnesota the fruticose thalli (pl. 42, B, facing p. 206) of *Usnea longissima*, which grows in tangled masses hanging over the branches of trees, frequently reach 1.5 meters in length, while the foliose thalli of *Gyrophora dillenii*, in the same portion of the State, sometimes reach 35 cm. in their longer diameter. Both fruticose and foliose thalli may vary from these large forms to minute ones not more than 0.2 mm. in height or diameter. In the crustose thalli the spread over or within the substratum may vary greatly, but is seldom more than 10 cm. In these and the foliose forms the thickness is to be taken into account. In the descriptions, however, actual measurements of thickness are very seldom given, though comparative statements are often resorted to. In the descriptions of the fruticose forms the diameters of the thalli or of their branches are usually given; and here again a considerable amount of variation is found, though very much less than in length.

SURFACES OF THALLI.

In the foliose thalli the upper surface is comparatively smooth, wrinkled, corrugated, or pustulate, and it may bear cilia, soredia,

or the minute growths known as isidioid branchlets. The margin of the thallus may be closely attached to the substratum (pl. 36, A, facing p. 194), or more or less ascending (pl. 30, facing p. 160). The lower surface is more or less covered with the attaching organs known as rhizoids. These may be large or small, numerous or few, and evenly scattered or collected into rows or into groups of different forms. The lower surface is sometimes quite smooth except for these rhizoids, but in other instances it is variously wrinkled or pitted, or in *Gyrophora*, provided with vertical plates which give strength.

In the fruticose thalli the surface is either smooth or more or less pitted, and in some instances it is somewhat tomentose. The *Cladonias* put forth as superficial outgrowths the flat expansions known as squamules. The *Stereocaulons* bear the peculiar structures more irregular in form called phyllocladia. The form, size, frequency of occurrence, and distribution of these organs must be noted carefully. In the *Cladonias*, especially, it is necessary to observe whether the cortex of the podetium is entire or more or less broken, so that it becomes areolate or even disappears over some portion of the organ. In this same genus observation with a lens is necessary to ascertain whether any part of the fruticose portion of the thallus is sorediate or not.

Finally, turning to the crustose thalli, they are also smooth or variously roughened. Those that are hypophlœodal or hypolithic simply take the contour of the surface of the substratum, as do also some thin and smooth forms that are in part or wholly epiphlœodal or epilithic. Others are scurfy or granular, and these are usually rather poorly developed and thin. In thicker forms is found the warty or verrucose condition; sometimes there occur here and there minute chinks, so that the thallus is said to be rimose or chinky; or finally the chinks may become numerous and divide the thallus into minute or small several-sided areas, known as areoles (pl. 8, B, facing p. 100), in which case the thallus is said to be areolate.

COLORS OF THALLI.

As compared with size and form, color is usually regarded as a rather more variable and therefore less reliable taxonomic character. Yet the colors of thalli play an important part in determining lichens and, though often quite variable, they must be carefully noted. Colors in lichen thalli vary all the way from a white to a black, but the most common is a greenish gray, in this paper designated as sea green. Some other colors which occur are ashy, olivaceous, brown, and straw color, together with various intermediate shades, as brownish black, olive brown, etc. The thallus, further, is often more or less variegated, while the lower surface is frequently of a different color from the upper. Also, in the fruticose forms the basal portion is frequently of a different color from the distal portions, usually darker.

The tendency of thalli, as of other lichen structures, is to darken with age, and the variations of color in a species may usually be traced to peculiar conditions of growth.

THE APOTHECIUM.

Likewise in the fruit, or apothecium, the main features of gross morphology are size, form, and color. The apothecia are usually superficial and large enough to be seen easily with the unaided eye (pl. 8, A, facing p. 100). In some instances, however, they are so small that they can be made out only with difficulty with the hand lens; or they may be immersed in the thallus and indicated at the surface by a slight elevation or depression as a disk or an ostiole (pl. 49, A, facing p. 235); or, when immersed, they may be scarcely discernible in any way except in sections of the thallus. From 0.1 to 5 mm. is well within the range for diameters of apothecia.

The apothecia are most commonly saucer-shaped, or some slight modification of this form, as when the disk is flat or somewhat convex instead of concave. In some instances the disk becomes very concave, the apothecium at last becoming cup-shaped. In other cases it is strongly convex, giving the apothecium at maturity a spheroidal form. In all of these forms the outline of a transverse section of the apothecium when young would usually be very nearly a perfect circle; but the form may become irregular as growth proceeds, so that at maturity this outline is quite irregular. In other lichens the apothecia are of some other form from the beginning. Thus, there are the elongated and often branched forms, such as are found in *Graphis* (pl. 2, A, facing p. 54), and the difform or variously irregular forms, as in *Arthonia* (pl. 2, B). Again, some apothecia are produced into a well-developed *perithecium*, and these usually approximate a spherical form.

THE DISK.

In those lichens in which the exciple (see below) is not produced into a perithecium the upper surface of the apothecium is naked, except for a very thin film of thallus which may persist as an *epithecium*, a structure not mentioned in the descriptions of species. This upper and essentially naked surface, whether flat or more or less strongly concave or convex, forms the disk. The outline of the disk, then, may be circular or variously elongated or irregular, varying in this respect with the form of the apothecium as a whole. In color the disk varies considerably even in the same species. It is usually light-colored in its early development and commonly becomes darker as it reaches maturity. The final color may be a light or darker flesh color or a light or darker shade of yellow, orange, red, brown, chestnut, olive, or even black. Whatever the color, it is very seldom

the same as that of the thallus. The surface of the disk, further, may be pruinose, usually with a white powder, concealing the essential color.

THE EXCIPIE.

Below the disk is the *hymenium* (pl. 3, fig. 3, *a*, facing p. 63), which may easily be seen in sections with the hand lens. This structure is usually lighter in color than the disk and is composed of paraphyses and asci. (See under minute morphology.) Below the hymenium is the *hypothecium* (pl. 3, fig. 3, *b*, facing p. 63), often darker in color than the hymenium above it, so that the line of demarcation between the two structures may easily be made out with the hand lens. The hymenium and hypothecium are mentioned here mainly that another structure, the exciple, may be located with reference to them. The exciple is a saucer-shaped or cup-shaped rim around the hymenium, consisting primarily of a continuation of the hypothecium upward on all sides. Such is the *proper exciple* (fig. 8, *b*, p. 60); but there is sometimes outside of this, or more often replacing it, what is known as a *thalloid exciple* (fig. 16, p. 232). This is similar to the thallus in structure, and usually of the same color, which is never true of the proper exciple, this usually approaching the disk in color. Either of the exciples may be entirely absent, and either or both may be quite evanescent and seen only in young apothecia; but usually one of them is present and either permanent or only tardily disappearing. It may be seen readily with the unaided eye or by the aid of the lens, and its nature and degree of development and permanence are points of considerable value in the classification of lichens, even to the determination of species. The perithecium, already mentioned, is simply a produced exciple found in some lichens, growing completely around the upper part of the hymenium but for the small opening or ostiole at the summit (fig. 17, p. 239). The margin of a proper exciple is usually about at the level of the outer margin of the disk, or it may be somewhat raised above the disk. This margin is almost always quite entire, while the margin of a thalloid exciple is frequently crenulate or crenate, or variously branched, ciliate, or irregular.

POSITION OF THE APOTHECIA.

Sometimes the apothecium is raised on a slender upward extension of the thallus, a short stalk or pedicel, quite different in form from the stipe and podetium soon to be described. This is most frequently met in the larger foliose lichens. The stalk may be absent and the apothecium attached to the thallus at the center of its lower side, in which case the apothecium is said to be *sessile*. Again, the apothecium may be more closely attached to the thallus by the whole of its lower side, when it is said to be *adnate*. Finally, the apothecium

may be more or less immersed in the thallus, sometimes deeply, so that when the disk is more or less overgrown by the thallus or by a perithecium the structures are often quite obscured. The development of the apothecium begins below the surface of the thallus, and the tendency in general is to become more and more superficial as maturity is reached. Sometimes, however, it remains permanently more or less immersed, and somewhat varying conditions as to position with reference to the thallus may be expected in many species.

STIPES AND PODETIA.

These are structures which serve to raise the apothecium into the air, and are both to be regarded as originally developed for this purpose. In such genera as *Calicium*, *Cyphelium*, and *Coniocybe* this is their only function, and where this is the case they receive the name of *stipes*. But in *Cladonia* and *Stereocaulon* the stipe takes up, in addition, the office of fostering algal cells and by its vertical extension and often ample branching greatly increases the area of surface behind which the algæ may find protection. In this case the structure is called a podetium, the proper stipe being devoid of algal cells. The stipe, therefore, belongs to the fruiting tract, while the podetium, doubtless modified from this, has the essential character of the thallus and more properly belongs to the vegetative tract.

RHIZOIDS AND CILIA.

The rhizoids are found on the ventral side of most foliose thalli and serve as attaching organs. They appear to the eye as root-like bodies, varying in color from white to black.

The cilia are like the rhizoids in structure, but are found on the upper surface of the thallus or along the margins. The hyphal rhizoids of the crustose lichens^a are quite different morphologically. The functions of cilia are doubtless to retain drops of water and gradually absorb them and sometimes, when quite numerous, to protect against cold or dust. Closely related to rhizoids is the single attaching organ known as the *umbilicus* on the ventral sides of the thalli of *Gyrophoras*, *Umbilicarias*, and many *Dermatocarpons*.

OTHER STRUCTURES.

Spermagonia, soredia, cephalodia, and cyphellæ are structures which occur on or near the surface of thalli. The spermagonia (fig. 3, p. 16) are the supposed male reproductive organs, sometimes quite conspicuous as dark-colored spots on the upper surface of the thallus, as in some *Parmelias* and other large foliose lichens; but these structures are more often minute and of the color of the thallus so that

^a See page 17.

they appear only in sections. They were formerly thought to be of considerable value in the determination of species. Their structure and functions will be further considered in the section on reproduction. The soredia are small, powdery masses, usually whitish in color, and scattered over the surface of the thallus as in *Pyxine sorediata* (pl. 48, facing p. 230) and many other lichens. They will be further considered in succeeding sections. Cephalodia are wart-like bodies found on the upper surface of the thallus as in *Peltigera aphthosa* (pl. 30, facing p. 160), or within the thallus, as in some other lichens. Cyphellæ are small pits or depressions in the lower surface of some foliose thalli as in some *Stictas* (pl. 26, facing p. 154). Cephalodia and Cyphellæ will be further considered under minute morphology, as their structure can be made out only with the microscope.

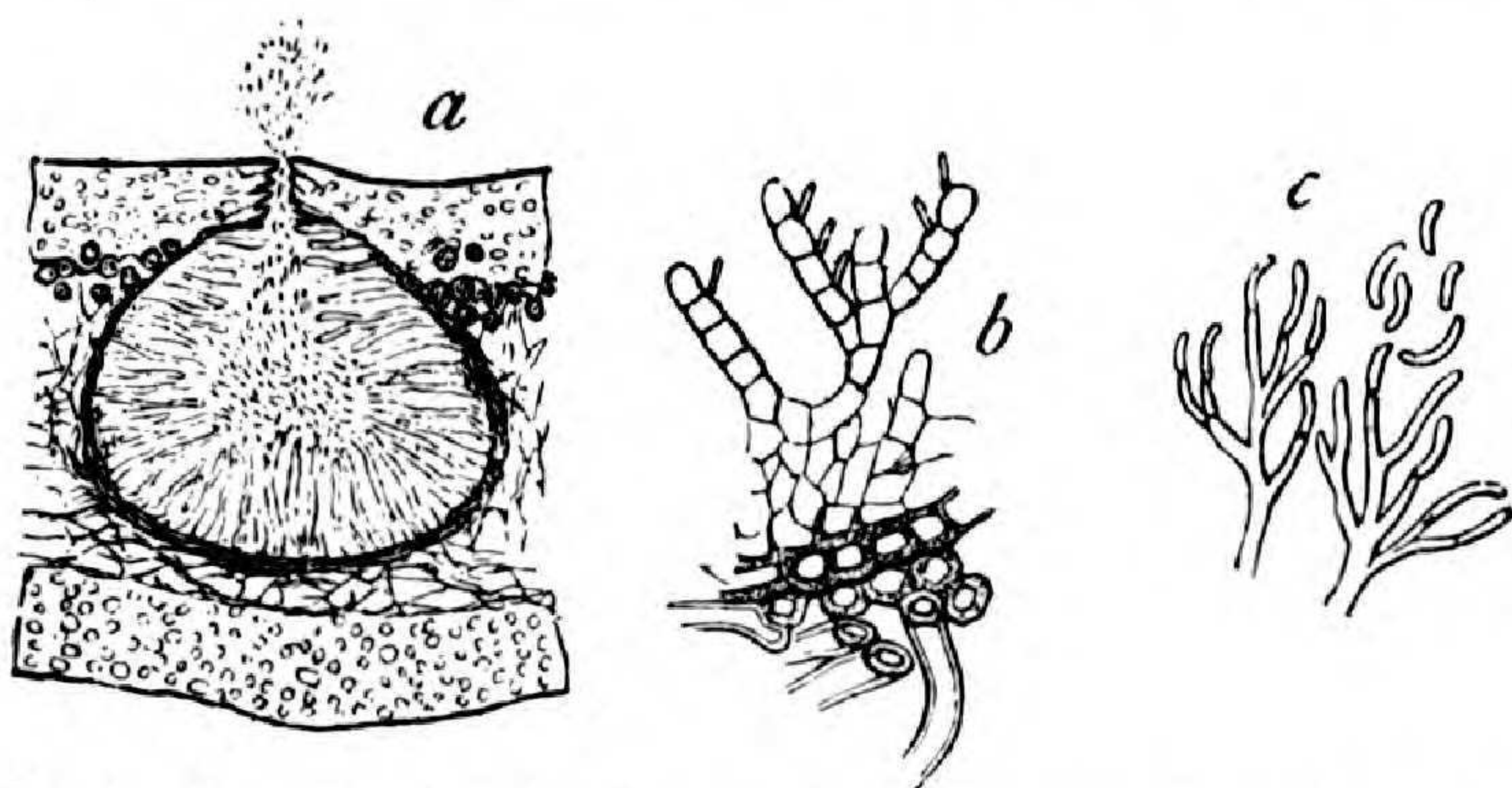


FIG. 3.—*Gyrophora cylindrica*. *a*, Median section through a spermatogonium; *b*, sterigmata and spermatia; *c*, sterigmata and spermatia of a *Cladonia*. *a*, Enlarged 90 diameters; *b*, 390 diameters; *c*, 450 diameters. *a* and *b* from DeBary; *c* from Tulasne.

the thallus. Its nature is not well understood, but possibly it is a remnant of some lichen that the *Pannaria* has overgrown. Some of the older authors considered the rhizoids a portion of the hypothallus. In the present work there has seldom been occasion to refer to this little-understood structure.

MINUTE MORPHOLOGY.

FOLIOSE THALLI.

In the foliose type of thallus there are the following layers: An upper dermis, an upper cellular cortex, an algal layer,^a a medullary layer, and a lower cellular cortex (fig. 4, p. 17). The dermis, however, is scarcely distinguishable in many foliose lichens, and there are several other variations from the structure just outlined. For instance, in *Collema* (pl. 21, facing p. 136) there is no cortex, and the algæ are not arranged in a definite layer; in some of the *Physcias* the cellular cortex is replaced by layers of densely interwoven hyphæ; in *Peltigera* the upper cellular cortex is present, but there is none below; a few small foliose thalli, as in some *Acarosporas* (pl. 32,

^a The algæ, however, are not strictly a part of the thallus but are inclosed within it.

Finally, in some lichens the so-called *hypothallus* is conspicuous to the unaided eye or seen with the lens. This is true of some members of the genus *Pannaria*. For instance, in *Pannaria nigra* this structure appears as a bluish black ring all around

facing p. 170), are cellular throughout. Other instances of similar modifications in structure will be met in the descriptions of the genera of Minnesota lichens.

CRUSTOSE THALLI.

In those crustose forms that are hypophlœodal or hypolithic, there is simply a tangled layer of interwoven algal cells and fungal hyphæ, without any differentiation into layers. In the epiphlœodal and epilithic species the structure may be quite as rudimentary, or there may be a more or less evident upper pseudocortex of interwoven hyphæ (pl. 4, fig. 4, *a*, facing p. 67). In instances of the latter kind there is frequently also a more or less distinct algal layer below the pseudocortex (pl. 4, fig. 4, *b*) and some representation of a medulla below the algal layer (pl. 4, fig. 4, *c*). Whether these superficial forms are thus differentiated or not, the modified hyphæ known as hyphal rhizoids may always be looked for penetrating the substratum. It is, however, very difficult to obtain them in sections of these thalli. With each description of a crustose genus will be found a statement regarding the amount of differentiation.

FRUTICOSE THALLI.

The fruticose type of lichen thallus is peculiar, and is for this reason treated after the crustose type. Fruticose thalli are usually, though as noted below not always, more or less cylindrical in form. The outer layer of the cylinder or other form is a pseudocortex of densely interwoven hyphæ, extending either in the direction of the axis or at right angles to it. Within this outer layer is the algal layer, which, like the outer layer of hyphæ, is commonly more or less nearly circular in transverse section (pl. 11, fig. 4, *a*, *b*, facing p. 107). Sometimes, as in *Alectoria*, there is within the algal layer a well-developed medullary layer filling the remainder of the space and making the cylinder a solid one. In other instances the medulla is poorly or scarcely at all developed. Within it, when only par-

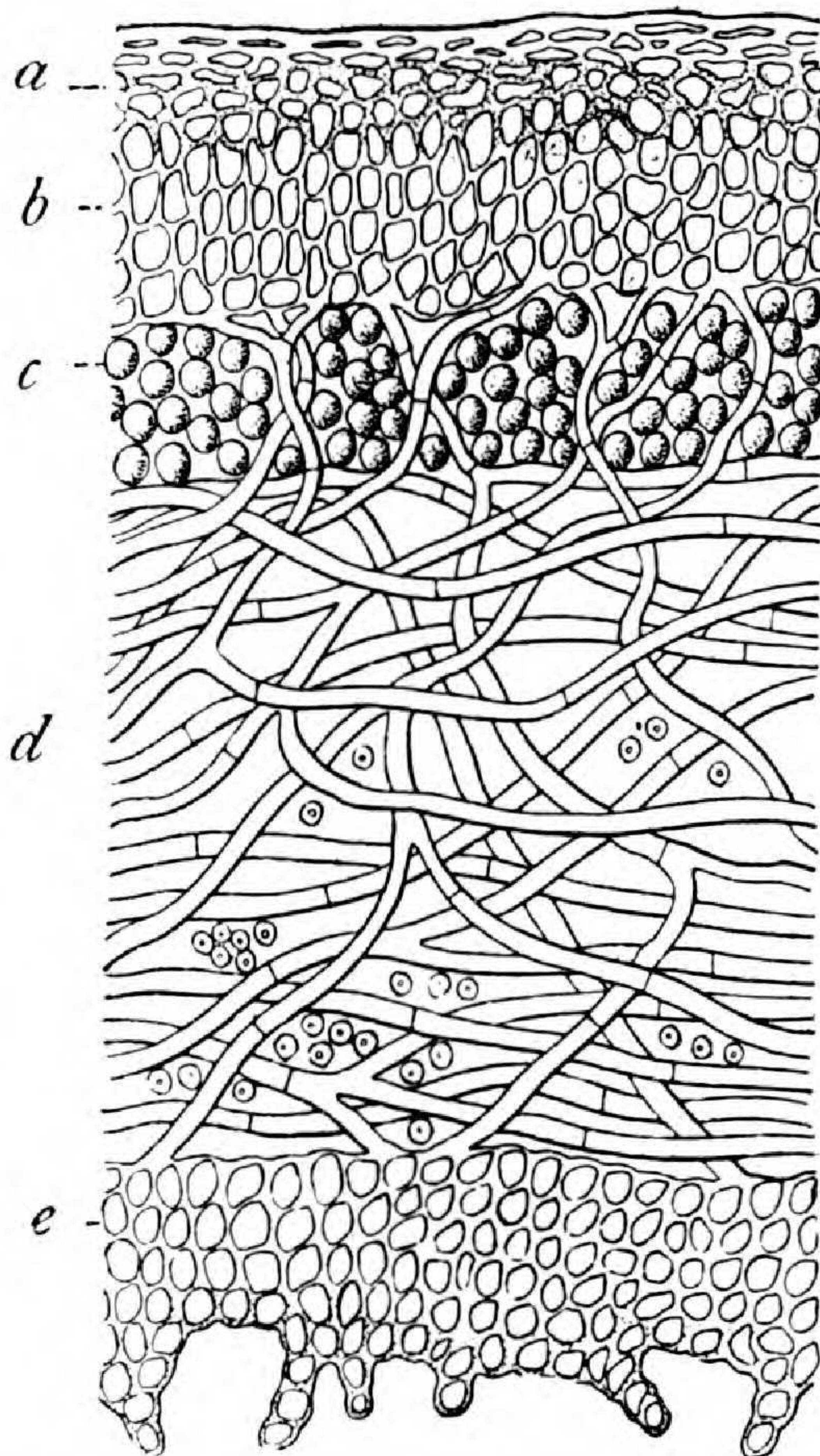


FIG. 4.—*Sticta amplissima*, section of the thallus. *a*, The dermis; *b*, the upper cortex; *c*, the algal layer; *d*, the medullary layer; *e*, the lower cortex. Enlarged 400 diameters. From Schneider.

tially developed or within the algal layer when the medulla is wanting, is frequently found a solid or a hollow cylinder of hyphæ extending in a longitudinal direction (pl. 18, fig. 3, *b*, *c*, facing p. 131). If this cylinder is hollow there are usually strengthening bundles of hyphæ to be found traversing the hollow central portion of the thallus in the transverse direction.

The outer pseudocortex is usually composed of hyphæ that are more or less gelatinized, so that the structure is very difficult to make out (pl. 11, fig. 4, *a*, facing p. 107). This gelatinization no doubt increases the protective function of the pseudocortex. The inner cylinder of hyphæ functions principally for conduction like a stele and the walls of the hyphæ show much less gelatinization. The algal layer is seldom a complete cylinder, the algæ more often appearing in clusters incompletely filling the space. The pseudocortex is seldom even approximately of the same thickness throughout and is sometimes scarcely at all developed except over the algal clusters. This arrangement brings the algal layer into closer contact with the atmosphere without completely exposing the algæ. The hyphæ are much less frequently branched in fruticose thalli than in foliose or crustose forms. In connection with this fact it is to be noted that fruticose thalli are not always even approximately cylindrical in form. Of the Minnesota species, *Ramalina calicaris fraxinea* departs most widely from the cylindrical form and appears much more like a foliose thallus growing away from the substratum, to which it is attached at a single point. However, when we section this thallus the structure is seen to be essentially that of the fruticose type. Indeed, in outward form, there is every gradation between the fruticose and the foliose thallus, and in a few so-called fruticose thalli there is found the cellular cortex characteristic of a foliose thallus.

THE DERMIS.

This structure consists of a few layers of flattened cells, lying upon the cortex and derived from it. The dermis aids in protection against excessive evaporation of moisture, and from its surface there sometimes arises a dense covering of short hyphæ which also functions in the same way. These are the *trichomatic hyphæ* of certain *Peltigera*s, and they also serve in *Peltigera apthosa* to help in retaining the soredia which develop into cephalodia. The dermis is rudimentary or wanting in most lichens except *Peltigera* and *Sticta* (fig. 4, *a*, p. 17). The inner layers of cells are less flattened and gradually pass into those of the cortex from which they are developed.

THE UPPER CORTEX.

This structure is cellular (pl. 9, fig. 4, *b*, facing p. 101), consisting usually of several layers. The cells of these layers may be as distinct

as those of any ordinary parenchyma or the walls may be gelatinized and swollen to such an extent that the cellular nature is not made out. This layer may appear quite hyaline in section or it may contain more or less of some coloring matter. In the majority of the foliose lichens such a structure is developed both above and below, and the lower cortex is more frequently of a dark color. However, as already stated, there are a number of foliose genera in which part or all of the species lack such a cortex on one or both sides. And it may be added here that in *Leptogium* (fig. 5) the cortex usually consists of a single layer of cells.

The cortex is constantly being built up from the hyphæ of the algal layer below and is gradually transformed above into a dermis. In this gradual upward passage of tissues dead algal cells become entangled and are at length carried off by the abrasion of the upper surface. The lower cortex is usually thinner and is more often absent than the upper; but in thalli in which this lower cortex is especially needed for mechanical support it is often better developed and thicker than the upper cortex.

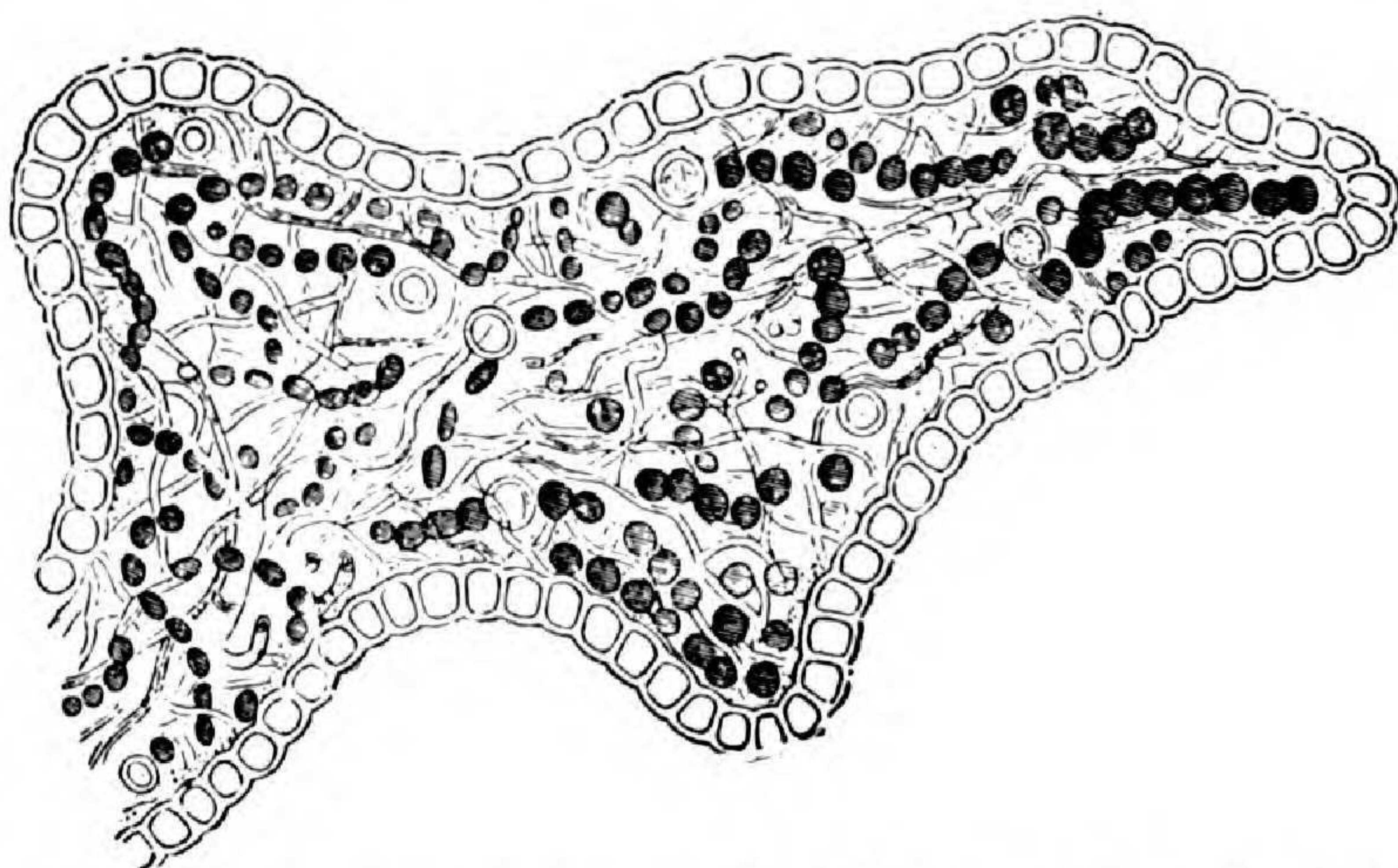


FIG. 5.—*Leptogium scotinum*, showing single layer of cells in the cortex and the intermingled fungal hyphæ and algal filaments within. Enlarged 550 diameters. From Sachs.

THE ALGAL LAYER.

In some instances, as in *Collema* (fig. 1, c, p. 9), the fungal hyphæ are simply in contact with the algæ and in others they are attached to them by haustoria. In some cases the haustoria penetrate the walls of the algal cells and they are then said to be intracellular. These naturally secure the closest union. Every gradation between intracellular and extracellular haustoria may be looked for in certain species, but it is rarely the case that the haustorium attains a full development, i. e., is divided into a network of hyphæ, within the algal cells. Indeed, intracellular haustoria are either very rare or not often distinguished as such. The extracellular haustoria usually consist of a network of short, thin-walled hyphæ growing over a large portion of the outer surface of the wall of each algal cell. Where these are present the food must pass through the wall of the haustorium and also through that of the alga, but in instances where the haustoria become intracellular the passage is through the wall of

the haustorium only. The algal cells of the algal layer are numerous in vigorous thalli, but in old and dying thalli few of them occur in the living state. The hyphæ of this layer give rise to the outer or upper cortex, whether a true cortex or a pseudocortex, and are also continuous with the hyphæ of the medullary layer. The food assimilated by the living algæ, together with that which the fungus may be able to take from the substratum through the rhizoids, the umbilicus, or the hyphal rhizoids, serves both for the production of new algal cells by division and for the growth of various portions of the thallus. As the algal cells die and pass outward new ones are constantly being formed toward the lower or inner portions of the algal layer, so that the thallus is always possessed of an abundance of this assimilative tissue. The growth and division of the algal cells is of course most active in young and vigorous thalli and in the younger and more active portions of older thalli.

THE MEDULLARY LAYER.

The medullary layer lies below the algal layer in horizontal thalli (pl. 35, fig. 3, *c*, facing p. 191) and within it in fruticose thalli (pl. 11, fig. 4, *c*, facing p. 107). This layer consists of loosely interwoven fungal hyphæ and is especially adapted to give strength by connecting the layers above with those below or those without with those within. It serves also as a medium for the free passage of gases much after the manner of the spongy parenchyma of a leaf. The differentiation into algal layer and medullary layer is not always perfect even in the best developed thalli, and algal cells may occur in small numbers in the latter layer. The medulla is quite commonly the thickest of all the layers of the thallus, and the section in this portion of the thallus is more constantly transparent or hyaline than in either of the cortical layers. As the hyphæ of this layer serve for giving strength, the walls are scarcely ever perceptibly gelatinized. Aside from the functions already named, the hyphæ of the medulla must carry up to the algæ any materials taken in a crude state from the substratum by the attaching organs, whether rhizoids, an umbilicus, or hyphal rhizoids. Also the foods assimilated by the algæ must in part pass downward or inward by means of these hyphæ for the nourishment of certain portions of the thalli. It is also supposed that fats and other food materials are often stored in the hyphæ of the medulla.

THE LOWER CORTEX.

In most respects the lower cortex is very similar to the upper, but, as already stated, it is neither so constantly present nor is it as a rule so thick. When the lower cortex is present the rhizoids extend from it into the substratum, but when it is absent rhizoids are usually present as

continuations of certain hyphæ of the medullary layer. Plainly such a cellular tissue on the lower side of the thallus must serve for support, and it becomes very thick in those large foliose thalli which are attached by an umbilicus, as *Gyrophora*, *Umbilicaria*, and *Dermatocarpon*. But, since it lies between the rhizoids and the tissue above, this cortical tissue must permit the passage of any crude or elaborated materials taken from the substratum by the rhizoids, for which reason it remains thinner than might otherwise be expected. Also, the lower cortex is usually a looser tissue than the upper cortex and is usually darker colored. *Peltigera* is a genus of large foliose lichens in which there is a well-developed upper cortex and no lower cortex, while in *Collema* (pl. 21, facing p. 136) and *Synechoblastus*, genera containing large foliose forms, there is neither upper nor lower cortex.

SOREDIA AND SPERMAGONIA.

A soredium consists of a tangled mass of algal cells and fungal hyphæ which has pushed upward from the algal layer and appears at the surface in a small spot where the upper cortex is broken. The soredia function for reproduction. The spermagonia (fig. 3, *a*, p. 16) appear as little spherical or cup-shaped bodies, sunken in the surface of the thallus. Within each spermogonium are borne the *spermatia* on stalks called *sterigmata* (fig. 3, *b*). The spermatium is a small, slender body, commonly colorless, and straight or slightly curved (fig. 3, *c*). The spermatia are usually regarded as male reproductive bodies.

CEPHALODIA.

These bodies sometimes appear upon the surface of the thallus and in other instances occur within it. Those situated on the upper or lower surface are called *ectotrophic*, and those that are found within the thallus *endotrophic* cephalodia. There is much difference of opinion as to the frequency of the appearance of cephalodia, due partly to lack of careful observation and partly also to difference of view as to their nature. A cephalodium is an abnormal development upon or within the lichen thallus, containing some other algal symbiont than the one found in other portions of the thallus. The cephalodia of our *Peltigera apthosa* (pl. 29, facing p. 159) are ectotrophic and plainly visible. The foreign algæ found in the cephalodia of this lichen are of the genus *Rivularia*, and they are supposed to be brought to the thallus in some way and, being held by the trichomatic hyphæ, to multiply and become surrounded by a true cortex. Ectotrophic cephalodia also occur in *Stereocaulons*, and the algæ contained are not always the same. But these are minute structures and seldom noticed. Endotrophic cephalodia are said to occur sometimes in *Sticta amplissima*.

CYPHELLÆ.

These structures are small pits found on the lower side of certain thalli. They are common in the majority of *Stictas* (pl. 26, facing p. 154). As lenticels commonly appear at points corresponding to the positions of stomata in seed plants, so the cyphellæ appear at points on the lower surface of the lichen thallus corresponding to the position of breathing pores. (See next section.) In their development a circular break first appears in the lower cortex, over the breathing pore. As the opening in the cortex increases in size, the adjacent hyphæ of the medullary layer give off numerous short branches, which fill the bottom of the opening so that the cyphella appears as a minute cup-shaped or saucer-shaped depression, whose bottom and sides are covered over with a dense coating of short hyphal branches. Indeed, in all of the Minnesota *Stictas* that contain cyphellæ these branches completely fill the cavity of the organ. The position of the cyphellæ over the breathing pores would seem to indicate that they serve to admit air to the interior of the thallus.

BREATHING PORES.

In lichens having a thallus well developed on both sides, it is evident that some provision for the admission of air to the interior will be advantageous. This is especially true where the cellular cortex is quite thick. The breathing pores of the lower cortex in *Stictas* have just been mentioned. Such structures are found in the lower cortex of many other lichens, but are even more common in the upper cellular cortex. They consist of more or less branched pores extending from the surface of the algal layer upward through the cortex in a somewhat irregular course and having no proper wall of their own but forming simply intercellular canals. They resemble stomata in that they can be closed, and also, as in the case of stomata, it is doubtful whether they are really of as much use for the exchange of gases as for some other purpose. They are found closed when the thallus becomes dry, and this doubtless helps to prevent the transpiration of moisture. Similar openings between the hyphæ of pseudocortices may sometimes be made out, especially when these cortices are quite thick. However, whether the cortex is cellular or not, these pores are to be looked for, for the most part, in the thinnest portions of the cortex, especially over areas where the algal cells are numerous.

GROWTH OF THALLI.

Since as a rule it is the fungus or the thallus proper which determines the form, the study of growth may naturally begin with this, though its growth is accompanied by an increase in the number of algal cells. In crustose and foliose lichens the growth is for the most part horizontal and mainly at or just behind the margin of the thallus.

The hyphæ in all portions of the thallus, however, may increase in length, either by the formation of new cells or by the elongation of old ones. In some instances the initial cells are equally active along the whole margin and the thallus is not lobed. But in some of the higher crustose species and the majority of the foliose species there are certain marginal areas where the initial cells are especially active, so that the horizontal growth is more active here than elsewhere. This uneven growth along the margin gives rise to the lobing so common in foliose lichens. Doubtless in the lower crustose lichens, where lobing is so uniformly absent, the frequent irregularity in form is due partly to irregularities in the surface of the substratum rendering growth more difficult at certain points than elsewhere, and in part also to loss of portions of epiphloeodal or epilithic thallus by abrasion. In all instances of lobing the form of the lobes is determined by the size and amount of activity of the areas of initial cells whose division forms the lobes. The thallus reaches its full thickness a short distance back of the growing margin. There is no further increase owing to the fact that, while new cells, both algal and fungal, are formed internally, abrasion of the general surface disposes of dead superficial cells to the same amount.

In most fruticose thalli the growth is mainly vertical instead of horizontal. There may be a single apical region, consisting of a continuous area of initials cells, and in such instances the thallus or the podetium will be unbranched. But in the great majority of instances there are areas of special activity, one corresponding to each branch of the thallus, whether horizontal, vertical, or lying at some intermediate angle. Here, as in all thalli, the manner of branching and the number of branches will depend upon the number and disposition of these areas of special activity.

But in some instances the growth of the thallus is essentially a growth of the algal instead of the fungal symbiont. This is the case in our *Ephebe pubescens* (pl. 24, facing p. 147), in which the alga branches dichotomously, has a single apical cell at the end of each branch, and determines both the growth and the form of the lichen.^a In *Collema* and *Synechoblastus*, where the algal cells are somewhat evenly distributed throughout the thallus, it is not very clear whether the algal or the fungal symbiont has more to do with determining the growth and form of the thallus. But since the growth is marginal and the irregular lobing seems to correspond to areas along the margin especially rich in algal filaments, it appears that the form is due mainly to the growth of the algæ. In the great majority of lichens, however, as already stated, the algal cells simply increase in number as the thallus increases in size. Thus the algæ always sustain a physiological

^a That is, according to the ordinary conception; but the real thallus is fungal and within the alga.

relation to the growth of the thallus and perform the function of assimilation for the fungal hyphæ.

THE APOTHECIUM IN GENERAL.

The fruit of a lichen is commonly called an apothecium, and consists of an epithecium, a hymenium, a hypothecium, and a thalloid or a proper exciple or both. Either or both of the exciples, however, may disappear, or the proper exciple may be produced into a structure known as a perithecium. Also, when a perithecium is present, it sometimes incloses an additional structure known as an amphithecium. These structures may now be explained in order.

THE EPITHECIUM.

This structure is supposed to be a film of the thallus extending over the upper surface of the apothecium, and its presence is explained by the fact that the development of the apothecium begins within the thallus and that the overlying part of this is carried up with the apothecium as it finally bursts through the upper cortex of the thallus. The epithecium is of the same color as the upper portion of the hymenium and is usually, when present, not distinguishable from it. Indeed, many of the older lichenists considered this portion of the hymenium a part of the epithecium and spoke of the epithecium as having certain colors, when the color was in the upper portion of the hymenium. In the descriptions to follow the epithecium has been ignored as something too rudimentary to be distinguished in an ordinary examination of a fruit, or, as probably in the large majority of instances, entirely absent in mature apothecia. Special statements are made, however, of the color of the upper portion of the hymenium when differing from that of the lower portion.

THE HYMENIUM.

The hymenium is composed of the asci or spore-containing sacs, and the protective filaments called paraphyses (fig. 9, *b*, p. 62). In position this structure lies below the epithecium and above the hypothecium. The asci are always thicker and usually shorter than the paraphyses, and the mature spores may usually be distinguished in them more or less plainly. It need be further stated here only that the asci and paraphyses usually are erect or suberect and constitute a densely packed mass composed of the two tissues.

THE THALLOID EXCIPIE.

This structure is commonly found in lichens having a well-developed thallus, whether fruticose or foliose, and is found, therefore, most commonly in the foliose lichens and least commonly in the crustose ones. In structure the thalloid exciple resembles the thallus (fig. 14, *b*, p. 178), with which it is always continuous. The outer layer of such

an exciple is directly continuous with the upper layer of the thallus, whether a true cellular cortex or a pseudocortex. This cortex of the exciple is often thicker than that of the thallus, to serve both for protection and support to the structures within and to aid in the dispersion of the spores. Within the cortex of the thalloid exciple there may be an algal layer and within this a medullary layer, but these two areas are by no means always clearly differentiated. There is no layer in any thalloid exciple that corresponds to the lower cortex found in so many foliose lichens. Occasionally the algæ may disappear from the thalloid exciple with age, but such a structure is still a thalloid exciple. The structure of the thalloid exciple is perfectly plain in instances where the apothecia are adnate, sessile, or pedicellate, but in instances where they are immersed it is by no means so easy to determine whether the portion of thallus surrounding should be regarded as a thalloid exciple. In some instances, also, where the thallus itself is of a rudimentary character and devoid of distinct differentiation into layers the thalloid exciple may be present in a similarly rudimentary condition, often simply as a thin veil, which may be quite evanescent.

THE PROPER EXCIPLE.

As the name indicates, the proper exciple is in reality a portion of the apothecium, being merely an upward extension of the hypothecium (fig. 11, *b*, p. 107) and, like it, either cellular in structure or composed of closely interwoven hyphæ. Both hyphal and cellular areas are found in a thalloid exciple, so that it is not always easy to distinguish between the two kinds of exciples by microscopic structure alone. The fundamental distinction is that if an exciple can be traced to the hypothecium (see below) it is to be regarded as a proper exciple, and if it can be traced to other portions of the thallus it is thalloid. But the thallus may be evanescent and disappear and a thalloid exciple still be present. In such instances the algal cells are usually present and the structure, further, does not appear to be continuous with the hypothecium. The hypothecium is always present, and the proper exciple may always be traced back to it in vertical sections through the center of the apothecium. Some authors seem to consider any exciple that does not contain algal cells a proper exciple, but such a disposition disregards morphological relationships and leads to confusion in the study of species. The proper exciple may be pale in section, or varying from this condition to a black color. It may be permanent or quite evanescent, and thin or very thick and conspicuous. It is a protective covering about the hymenium and is often produced into a perithecium, which completely surrounds the hymenium, except for the ostiole at the summit. The proper exciple also aids in the dispersion of spores.

THE HYPOTHECIUM.

This area lies immediately below the hymenium (fig. 9, *b*, p. 62) and varies considerably both in thickness and structure. Sometimes it exceeds the hymenium in thickness, but in most instances it is considerably thinner in vertical section. In structure it may be composed entirely of hyphæ (pl. 3, fig. 3, *b*, facing p. 63) or entirely of cells (pl. 11, fig. 3, *b*, facing p. 107) similar to those of a cellular cortex, or it may be partly cellular and partly hyphal. In some of the higher lichens, even when the structure is hyphal throughout, the hypothecium is more or less plainly differentiated into two layers, with the hyphæ extending in a general vertical direction in the upper layer and more nearly horizontally in the lower layer (pl. 40, fig. 3, *b*, *c*, facing p. 204). This differentiation may sometimes be made out in some of the lower lichens, and in some instances where the structure of the hypothecium is cellular throughout there is a similar differentiation into an upper and a lower layer. The cells and hyphæ of the hypothecium are smaller than the similar structures of the thallus, and the walls are more inclined to become gelatinized so that the structure is obscured; and the same statement applies to the proper exciple and the perithecium, which when present are continuations of the hypothecium. The color of the hypothecium, like that of the exciple, varies from the palest shades to black, and likewise the sections may appear perfectly hyaline. Both exciple and hypothecium often become darker with age, so that there may be a considerable amount of variation in color in the same species.

THE AMPHITHECIUM.

In those lichens in which the proper exciple is produced into a perithecium there is sometimes a dark layer outside and a lighter and often hyaline layer within between the dark outer covering and the hymenium. This inner layer is known as the amphithecium. In some pyrenocarpic lichens, in which the apothecia are immersed in the thallus, as in *Dermatocarpon* (fig. 18, p. 243), the dark, outer protective layer is not needed, and the whole of the tissue surrounding the hymenium is here hyaline or colorless, and this also is known as an amphithecium.

THE PARAPHYSES.

These structures are specialized hyphæ which arise from the tissues of the hypothecium. They are commonly cylindrical in form and divided by transverse walls into a number of cells. They appear at a hasty examination to be uniformly simple in most lichen species, but more careful observation usually brings to light some that are branched in nearly every hymenium. The branching may be

very limited (pl. 45, fig. 5, facing p. 217), or it may be extensive, as in most *Arthonias*. Careful statements as to the branching are made with the description of each species, but branching is so common and its character so difficult to trace that it may well be doubted whether the branching has any great diagnostic value. The paraphyses are usually distinct, but sometimes the walls are more or less gelatinized and the whole structure in some degree coherent and indistinct. They are usually longer than the asci, but are shorter than these in the case of the *Verrucarias*, in which they also become imperfectly or often wholly gelatinized. The tips, or apices, are usually thickened and darker in color than the remaining part. Other portions of the paraphysis may be somewhat colored; but usually the single organ appears quite hyaline, though the section of the hymenium often shows color. The functions are those of protecting the asci and the contained spores against too rapid transpiration and of aiding in the dispersion of the spores. The thickening and coloration of the apices aid in the protective function.

THE ASCI.

The asci arise, like the paraphyses (pl. 18, fig. 3, *a*, facing p. 131), from the tissues of the hypothecium, or also from special ascogenous hyphæ. They are usually shorter and wider than the paraphyses which surround them. In form they are most commonly clavate, but they may be cylindrical, pyriform, subglobose, or variously ventricose or otherwise irregular. The walls are usually more or less thickened toward the apex, probably by an accumulation of epiplasm (pl. 18, fig. 5, *a*, facing p. 131). The thickening may be very slight or it may occupy the upper third or more of the entire length of the ascus, as in some *Arthonias*. There is a succession of asci produced in each apothecium, and one may rarely find asci of two generations together, those of one generation containing mature or perhaps old and shriveled spores, and those of the other younger, larger, and unshriveled ones, perhaps also immature, as shown by color or condition of cell division. In *Calicium* and other closely related genera the upper portion of the wall of the ascus becomes gelatinized and dissolved before the spores are mature, and the spores escape and ripen in the hymenium outside the asci. In other ascomycetous lichens the spores mature within the asci, which then open at the apex for their escape. The apical wall may rupture irregularly, the end may become torn across in some regular way, or probably in many instances an apical plug is pushed out, as in some other ascomycetous fungi. However, there is lack of any extended observations as to the method of opening of the ascus in lichens.

THE SPORES.

These bodies are usually eight in each ascus and rather small in size, but the number may vary from one to many and the size is inversely proportional to number, varying from $3\ \mu$ to $200\ \mu$ or more in length. (See pls. 3, 4, 9, 11, 18, 21, 22, 24, 32, 35, 40, 46.) The most common forms are oblong or ellipsoid, but the spores vary from acicular to spherical. Usually the size and form are quite constant in a given species, but there are instances of considerable variation even in the same hymenium.

The spores as arranged in the ascus may be uniseriate, oblique, side by side, or more or less irregularly placed. They are likely to be side by side when acicular in form, uniseriate when spherical or oblong in a cylindrical ascus, and obliquely or irregularly arranged when the ascus is pyriform, thickly clavate, or ventricose-clavate.

The spores may be simple, two-celled, four-celled, or several-celled, the cells being, in most of the compound conditions, arranged in a single series, separated by transverse walls. Besides the transverse divisions, others may be formed in the direction of the long axis of the spore, giving what is known as a muriform spore. In the development of the muriform spore the transverse walls always appear first, and in some species of lichens usually only a portion of the spores are ever found in the muriform condition, though the others are probably to be regarded as immature. The polar two-celled spore is a peculiar form found in *Teloschistes* and *Placodium* in which the two cells are far apart, one at either end of the spore.

In color the spores vary from hyaline to a blackish brown. Simple spores are usually hyaline, but there are exceptions to the rule. Compound spores are very frequently more or less colored.

The spores are not always easily distinguished in the ascus, especially in rather thick sections. To bring them out better, the section may be carefully crushed on the slide, but one must always be sure that he sees the spores in the ascus, otherwise he may observe the spores of some other lichen and determine his specimen incorrectly. After making sure of the number of spores in each ascus and of their form and color, some may be studied outside of the ascus for the purpose of getting size, form, color, and structure more accurately. Minute spores may be mistaken in the ascus for the granular protoplasm of an immature ascus, and the acicular spores are also sometimes difficult to distinguish in the ascus.

THECIAL ALGÆ.

In some lichens there are found in the hymenium certain algal cells, commonly known as thecial or hymenial algæ. These algæ (fig. 6, p. 29) are usually smaller than those of the thallus, and are

perhaps of the same species, varying in size because of a difference in nutrition; but it is by no means certain that the thecial algæ are derived from the thallus of the lichen in which they occur. Among the Minnesota lichens they may be looked for especially in mature plants of *Dermatocarpon* and *Endocarpon*, though they may occur in some other closely related types. The algal cells are usually smaller than those of the thallus, and are often found clinging to the asci or to the paraphyses. By some it is supposed that they are dispersed with the spores and are at hand when the spores germinate, so that the symbiotic relation may be established at once and a thallus readily built up, provided other conditions are favorable. However, it may well be doubted whether reproduction often takes place in this way in nature, and it is much more probable that the main function of these algal cells is to nourish the fungal tissues within the apothecium. The fact that thecial algæ are more common in immature than in mature apothecia would favor this view. They are found in many immature apothecia of other lichen genera, but seldom persist. Doubtless these nonpersisting thecial algæ at least are foreign organisms which, having gained access to the young apothecia, endure for a time under more or less unfavorable conditions.

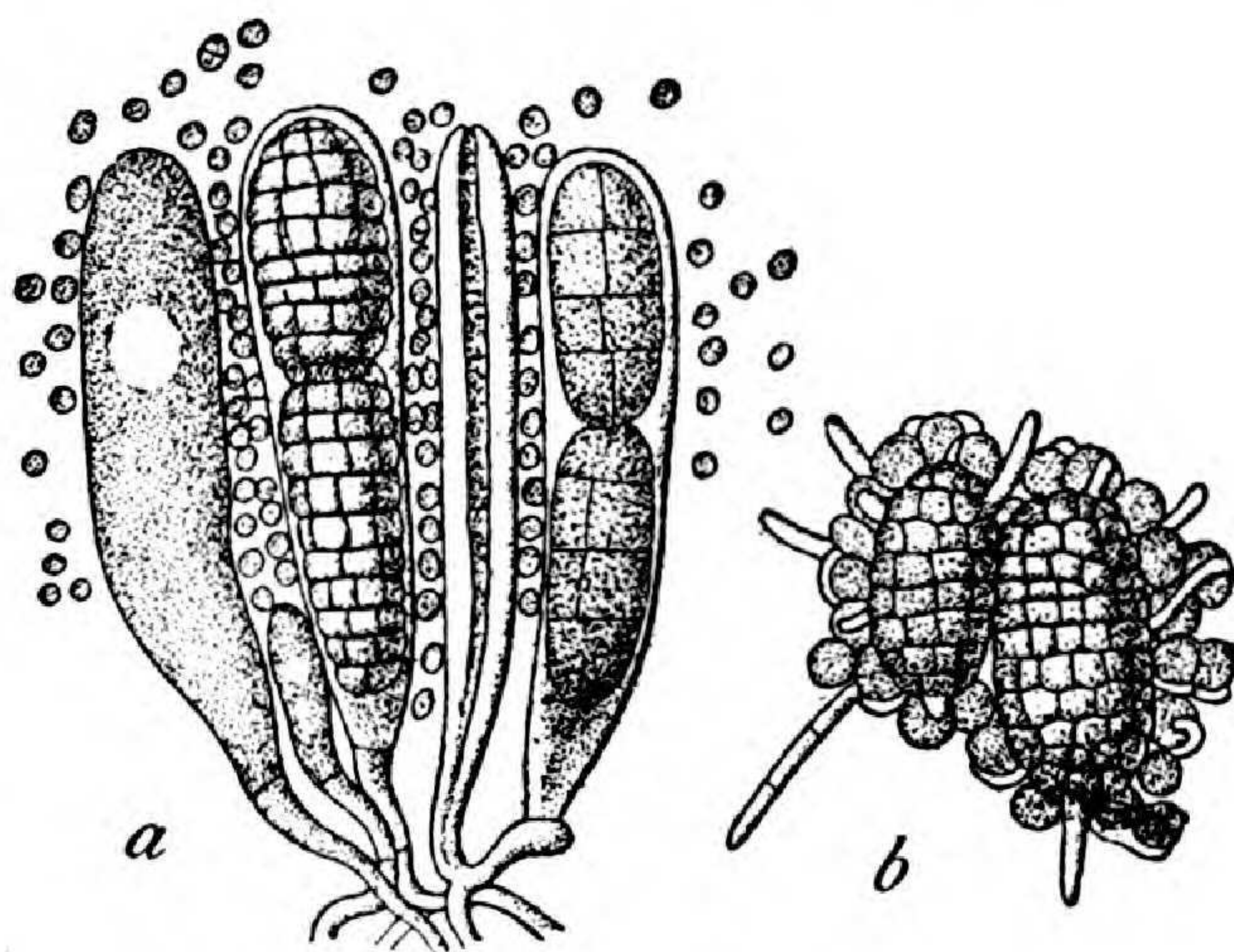


FIG. 6.—*Endocarpon pusillum*. *a*, The hymenial algæ intermingled with the asci and the paraphyses; *b*, two germinating spores surrounded by hymenial algæ. Enlarged 320 diameters. From Stahl.

DEVELOPMENT OF THE APOTHECIA.

This subject has been studied by various observers in Europe and America, and the origin and development seems to be very similar to that in the Ascomycetes in general. The first thing to be observed in the development of an apothecium is a mass of closely interwoven hyphæ below the algal zone, in the medullary area—this, of course, in those lichens in which there is a distinct differentiation into thallus layers. In *Collema* and some related forms, this differentiation is wanting, but the development here also begins within the thallus. The crustose lichens, which are without the layers, have not been carefully studied as to apothecial development.

The mass of hyphæ constitutes the beginning of the development of the hypothecium, and the structure increases rapidly in size, spreading out laterally and also increasing in thickness. From the

hyphæ of this young hypothecium arise vertical hyphæ, which soon become differentiated into paraphyses and asci, appearing first over the central portions of the mass of hyphæ and extending laterally in all directions as the hypothecium spreads out by lateral growth. The paraphyses and the asci are very similar in their early development, but the hyphæ which produce the asci very soon begin to enlarge so that the asci may be distinguished from the paraphyses while still very small. Also these asci-producing hyphæ always remain one-celled and are much richer in protoplasm than the others. Observers have thought that the asci and paraphyses arise from different systems of hyphæ and have called the supposed asci-producing elements ascogenous hyphæ, regarding them as arising from ascogonia. But more recently Sturgis, in this country, has arrived at the conclusion that both asci and paraphyses arise from the same system of hyphæ. More investigation is needed at this point. As the development proceeds the hypothecium is produced into the exciple or the perithecium, as the case may be.

Beginning its development within the thallus, the apothecium may remain immersed or it may become more or less superficial, being supported in the ways already described. As the apothecium pushes upward the surrounding thallus may or not grow up about it to form the thalloid exciple, and now, if at all, is formed the epithecium.

REPRODUCTION.

SOREDIA.

Among the means of reproduction in lichens soredia play an important part. These masses of fungal hyphæ and algæ may in proper environment produce a lichen thallus. They occur on many foliose and fruticose lichens and on some crustose species. A whole soredium or a portion of one is easily carried by the wind, and resting on a favorable substratum may develop into a lichen thallus having the same structure and bearing the same kind of apothecia, soredia, spermagonia, etc., as that on which the soredium developed.

There is no differentiation into layers in the soredium, nor is dorsiventrality established until after it begins to grow on the substratum. As growth begins, the hyphal rhizoids penetrate the substratum to secure nourishment and to anchor the minute mass of tissue. As growth proceeds, the fungal portion of the soredium usually becomes differentiated into cortex and medulla, and the algæ come to occupy their proper place in the thallus.

Soredia may develop on the thallus on which they are produced, into the isidioid branchlets frequently found on the thalli of some of the foliose lichens. Doubtless the reproduction by soredia is the most important method in many lichens. Indeed, a considerable

portion of the foliose lichens and a few fruticose and crustose ones seldom produce apothecia and spores.

FRAGMENTATION.

Another method of vegetative reproduction among lichens is by fragments of thalli becoming detached and blowing away and growing upon a suitable substratum. It does not matter how small the fragment provided it contains both the algæ and the fungal hyphæ. There may be all the layers of the thallus represented in the fragment or not. Sometimes the fragment is an isidioid branchlet and in other instances it is a large and conspicuous portion of the thallus. The latter condition is well illustrated in *Usnea longissima*, long masses of which are often seen in northern Minnesota hanging over branches, without any attachment whatever. In foliose and crustose lichens also the fragments may be large, and even whole thalli may be torn loose by the wind and transported to a new substratum and there grow.

REJUVENESCENCE.

In a considerable number of lichens the older portions of the thallus die while the younger portions continue to grow. This condition is quite common among Cladonias, where the basal portions of the podetia die and the branching above continues. The branches thus become separated and a number of individuals arise from one. Usually such an assemblage forms a dense cluster, but the central and more raised portion of the cluster frequently dies or is blown away, leaving a continuous or more or less broken ring of plants. In foliose and crustose lichens the central portion of the thallus often dies and the outer portions form a "fairy ring." The ring often becomes discontinuous, and thus a number of individuals arise from one. The dying at the center may be due to age or to the exhaustion of food substances from the substratum. *Lecanora muralis* and *Lecidea speirea* are species of crustose lichens in which this method of reproduction is often seen (pl. 33, facing p. 175).

SPORES.

The spores of lichens have repeatedly been proved to be capable of germination in cultures and of producing the usual forms of thalli of their species, both when sown with the algæ and when sown without them in favorable nutrient media. But the question still remains whether lichens are often produced from spores in nature. Evidently, except in the instances of germination in certain culture media, the spores of lichens must happen to come into contact with the alga of the same species as the one that forms the algal symbiont in the species of lichen by which the spore was produced. And, in addition, the conditions, substratic and other, must be sufficiently

favorable for germination and the production of a new lichen individual. It may well be doubted whether such a combination is likely to come about often enough that among lichens spores may be regarded as important agents in reproduction. The chances of reproduction by spores were plainly decreased greatly when the symbiotic relationship was taken on, and the result has in all probability been a considerable physiological degeneration of the spores in the course of phylogenetic development.

SEXUAL REPRODUCTION.

The sexual processes have not been studied in very many of the fungi most closely related to the lichens, but recent discoveries seem to indicate that sexuality is common there and in the ascomycetous lichens as well. In *Collema*, Stahl and others have found that the

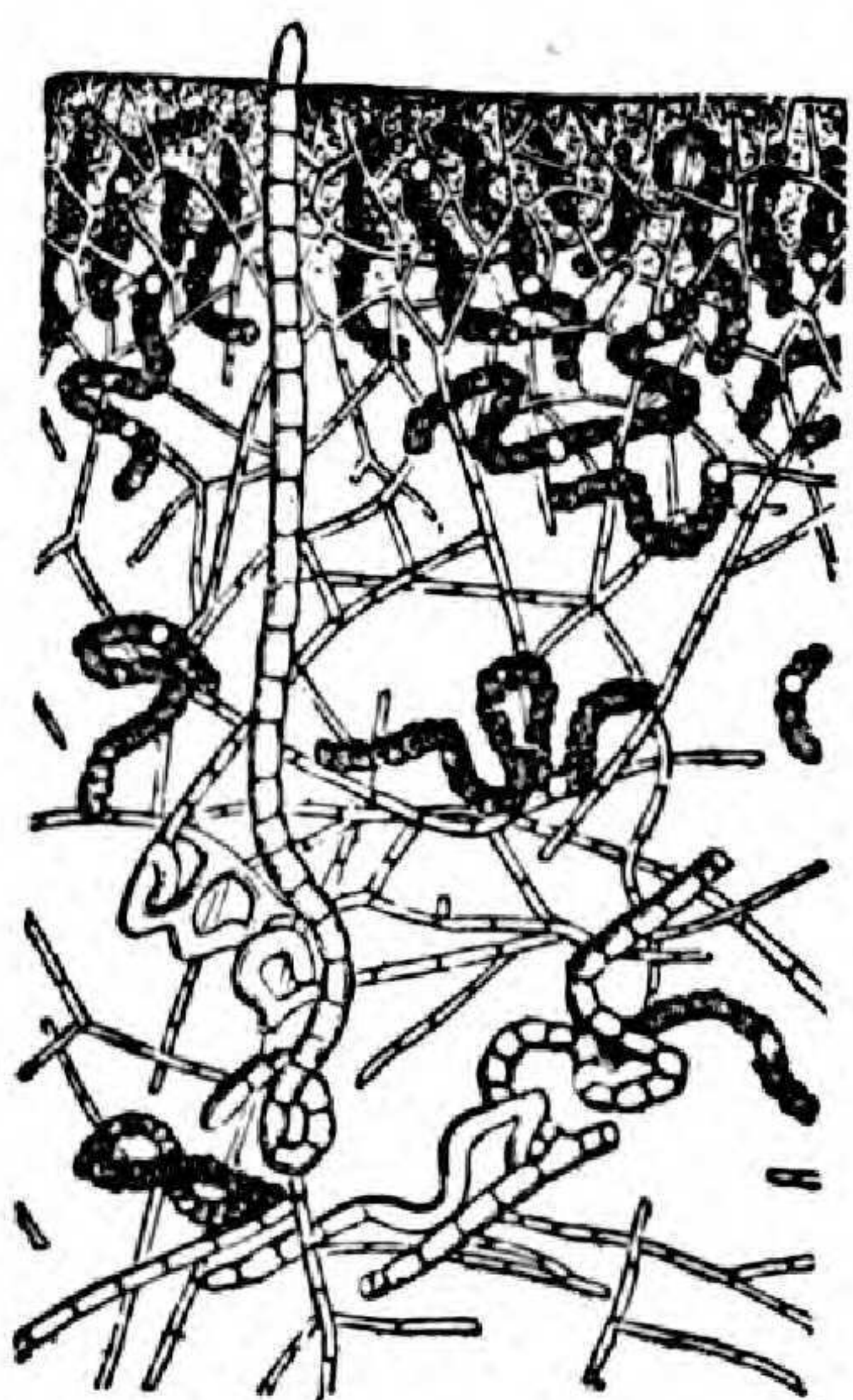


FIG. 7.—*Collema microphyllum*, showing the archicarp and the trichogyne. Enlarged 300 diameters. From Stahl.

apothecium is preceded by an archicarp and a trichogyne (fig. 7), which are supposed to constitute a reproductive tract. The more recent researches of Baur, Darbishire, Lindau, and Wainio have proved the existence of similar tracts in lichens of several genera, and while there is yet much need of research regarding nuclear behavior, the general presence of sexual organs in lichens can scarcely be questioned longer.

The spermagonia have been supposed to constitute the male reproductive organs of lichens, and Stahl thinks that he has established beyond reasonable doubt that fertilization actually takes place, the spermatia (fig. 3, c, p. 16) from the spermagones (fig. 3, a) becoming attached to the apex of the trichogyne, where a transfer of protoplasm occurs. Strangely enough, Möller, experimenting on lichens not closely related to *Collema*, has produced from the spermatia thalli in all respects similar to those which he obtained from spores. This would seem to indicate that the spermatia, if they are sexual cells, have become so degenerate in certain lichens as to lose their sexual function, becoming capable at the same time of reproducing vegetatively. However, it is supposable that the spermatia may not be degenerate but capable either of functioning for sexual reproduction or of developing parthenogenetically. It seems necessary to add that some botanists regard the spermagones as bodies belonging to fungi parasitic on the lichen thalli.

The question of the sexuality of lichens, together with that of the origin and development of the apothecium, has in the last half century excited quite as much interest as the one regarding the nature

of lichens, and one quite as much as the other is in need of further elucidation.

ECONOMIC RÔLE OF LICHENS.

Lichens are among the most widely distributed of plants, and the traveler will find them wherever he may go. To the far north the species seem to decrease somewhat in number, but in the arctic and subarctic regions some of the plants reach considerable size and serve for food, both for man and for lower animals. Lichens are common in tropical regions also; but here they have not been so frequently resorted to for food. These plants have been used in the arts and for medicine, and they also play an important rôle in nature as purifiers of the air and in the reduction of rocks to soil.

AS PURIFIERS OF THE AIR.

Lichens take large amounts of carbon dioxide from the air, in the process of nutrition build up lichenin, a carbon compound very similar to starch, and return to the atmosphere as free oxygen the portion not needed in the production of lichenin and other compounds within the plants. It was formerly supposed that the lichens took a very small portion, if any, of their food from the substratum, but that view is certainly incorrect, at least in the case of many species. However, it is quite likely that most lichens take a smaller part of their food from the substratum and a larger part from the air than do the higher chlorophyll-bearing plants. But it is certain that the fungus forming the lichen takes more or less of crude or elaborated food materials from the substratum, while the algal cells of the partnership do the work of building up the lichenin. Thus lichens, in the ordinary processes of nutrition, aid in purifying the air by extracting carbon dioxide and giving back to the air a portion of the oxygen in the free condition. Lichens are very sensitive to conditions of the atmosphere and are becoming scarce near our cities and larger towns. This is due partly to the disturbance of substrata, but it is also true that the dust and the impurities of the air about cities are in some way unfavorable to the lichens. Doubtless the dust fills the pores of the thallus and interferes with the passage of gases, while some impurities interfere with nutrition and respiration. It is not the intention to give the impression that lichens are the great conservators of atmospheric purity, but rather that they contribute their share of work toward this end.

AS AIDS IN ROCK DISINTEGRATION.

It is well known that certain crustose lichens are the first plants to attack rocks and that they aid greatly in the reduction of rocks

to soil. It would seem from superficial observation that some lichens begin to grow on perfectly firm rock and, gaining a foothold, reach their full size and produce fruit while the rock is still in a firm and wholly undisintegrated condition. For instance, on the very hard Sioux quartzite in southern Minnesota the lichens are growing on perfectly smooth surfaces supposed to have been polished by the wind near the close of glacial times. Yet this rock shows to the eye or lens no evidence of disintegration and is, macroscopically, in exactly the same condition under the lichens as elsewhere. But in spite of this it is not supposed that the rhizoids of the lichens ever penetrate perfectly firm rock, but rather that the plant gains a point of attachment, perhaps in microscopic openings, and then begins to secrete an acid which slowly disintegrates the rock, the rhizoids penetrating deeper and deeper as the work of the acid makes a way for them.

In other portions of Minnesota may be found crustose lichens growing on rocks that have not yet fallen to fragments but are so rotten for several inches below the surface that they can easily be powdered by the foot. The work of rock disintegration is aided in its early stages by the lichens, and especially by the crustose forms. As the rock at the surface is gradually reduced to small fragments and soil the crustose lichens decay and add their quota of humus. On this bit of prepared earth, in some crevice or on a flat surface of rock, the foliose and fruticose lichens and certain mosses begin to appear and carry on the work begun by the crustose lichens. Then in turn appear ferns, herbaceous seed plants, and finally shrubs and trees, first in the crevices and at length over the whole surface, until the lichens are largely replaced by larger vegetation.

AS FOOD.

It is doubtful whether even the wild animals eat lichens to any considerable extent so far south as the pineries of northern Minnesota, for the reason that there is too much other available food. But it would not be surprising if some careful observations in winter would show that the moose, caribou, and deer eat the "reindeer moss," *Cladonia rangiferina* (pl. 12, facing p. 111), and other large Cladonias to some extent. Farther northward the reindeer moss and some other lichens are important as food for both man and lower animals. *Cladonia rangiferina* and two or three closely related species form the principal food of the reindeer and become in Lapland relatively as important as some of the grasses of our prairies. This happens for the reason that the larger plants do not drive out the lichens so effectually in regions to the north, so that the reindeer moss and some other lichens there cover large areas like the grasses in our

region. Some suggestion of this wonderful lichen growth may be seen in northern Minnesota, where patches may be found covering an acre or more of ground. Also in northern regions, both in America and Europe, other wild and domestic animals depend more or less upon these lichens for their food supply.

Lecanora esculenta grows loosely attached to the rocks in high places in northern Africa, is carried long distances by the wind, and, falling in areas where food is scarce, is eaten by the inhabitants, both man and lower animals. This plant is supposed to have been the manna of the children of Israel. Nor is this the only lichen eaten by man, for *Cetraria islandica*, the well-known "Iceland moss," forms an important part of the food of the people of Iceland, as well as of their domestic animals. This *Cetraria* is especially rich in the peculiar starch-like compound so commonly built up in lichen tissues. Also some of our Gyrophoras and other common lichens, as *Ramalina calicaris*, *Parmelia physodes*, *Peltigera canina*, and *Evernia prunastri* (pl. 39, facing p. 203), have been used as food by man.

The nutritive value of lichens is due mainly to the lichenin, or starch-like material. But there is a bitter substance found in the lichen which often gives an unpleasant taste and is irritating to the digestive tract. This may be removed by thorough washing in water or some alkali, after which the plants may usually be eaten with impunity.

When grains or potatoes are at hand, the lichens may be powdered and mixed with these articles of food and a very palatable bread may be made.

AS MEDICINAL AGENTS.

A considerable number of lichens have been used for medicinal purposes, but few of the supposed medicinal properties have been able to stand the test of modern medical science. Thus the "dog lichen," our common *Peltigera canina*, was formerly supposed to be curative of hydrophobia, hence the specific name. Likewise *Sticta pulmonaria* was supposed to cure pulmonary diseases, while the well-known *Usnea barbata* was supposed to promote the growth of hair and to be a sort of cure-all. *Evernia vulpina* is said to have been used, mixed with other substances, to poison wolves. Lindsay, in his Popular History of British Lichens, states that *Cetraria islandica* furnished preparations which were to be found in the drug stores of England at the date of publication of his volume, 1865, as curatives for dyspepsia, and we still find *Cetraria* given in our latest dispensaries as a remedy. It is the bitter principle of the lichens that is supposed to give them medicinal value, and it has been used in fevers, as a tonic, and as a purgative, as well as in the other ways mentioned above. Also, alcohol has been made from lichens.

AS DYESTUFFS.

Dyes of various colors have been extracted from lichens. The colors are usually reds, purples, or blues, and the dyes have been used for coloring cloth, wood, paper, etc. In Europe they have been quite largely employed in coloring homespun cloth and yarn, our common *Parmelia saxatilis* being ordinarily used, producing various colors according to the method employed in making the dye. In *Evernia vulpina* the yellow coloring matter is ready formed in the thallus, and the same may be said of the beautiful yellows and oranges of our *Teloschistes* and *Placodiums*. Brown colors are also ready formed in many lichen thalli, are easily extracted, and have been used for home consumption.

Most of these dyes are not to be had in sufficient quantities to be manufactured for the markets. However, *Roccella tinctoria*, a lichen found on our Pacific coast and on various coasts of the Old World, produces a pigment which has been known by one name or another since earliest historical times. "Orseille" is one of its names and "litmus" another. This is no doubt the "blue and purple" of the Old Testament, and in more recent times the same dye has been extensively used in France for coloring silks. At the present time paper is colored with a neutral solution of the dye and used commonly in chemical laboratories as litmus paper. Litmus is also found in the market as a carmine powder and as an indigo blue. In obtaining these lichen dyes, the thallus is pulverized and then some alkali is applied for the extraction of the coloring matter.

AS RELATED TO THE WELFARE OF TREES.

In France and other countries of Europe foresters have supposed that lichens are injurious to the trees and have to a limited extent practiced scraping the larger ones from the bark, along with certain other fungi. However, it would be difficult to accomplish much in this way in large forests, even were it known that the lichens are very injurious to the trees. In our country M. B. Waite, while experimenting with fungicides on fruit trees, noted that the Bordeaux mixture killed the lichens very effectually. He is not at all certain that the lichens are injurious to the trees, but thinks that they may at least interfere with the functions of the bark. It is true that the more conspicuous foliose lichens are more common on unhealthy trees than on thrifty ones (pl. 37, facing p. 195), but the question remains whether the lichens have worked the injury to the trees or whether unhealthy trees are more easily penetrated by the rhizoids of the lichens, and also whether they furnish some food materials for the lichens not present in healthy trees or not easily obtained from them. It is probably not worth while to take time to remove lichens from any trees of temperate regions for the sake of saving the trees from injury.

DESCRIPTIVE CATALOGUE.**OUTLINE OF CLASSIFICATION.****CLASS LICHENES.****ORDER ASCOLICHENES.**

Lichens in which the spores are produced in asci. All of the Minnesota lichens belong here, except perhaps the last family below, in which the fungal symbiont may not be an ascomycete. The order Basidiolichenes includes but a few species and is confined to tropical regions.

SUBORDER CONIOCARPINEAE.

The thallus is crustose, and the alga is *Cystococcus*, except perhaps in *Coniocybe*. The fungal symbionts belong to the *Protocaliciaceae*. An erect and rarely branched structure, the stipe, arises from the substratum and bears the exciple and the hymenium. The stipes are devoid of algal cells and are to be regarded as parts of the apothecia rather than portions of the thallus. A proper exciple is present. The plants are minute and are difficult to detect; the stipes when best developed are only 0.2 to 2.5 mm. long.

FAMILY CALICIACEAE (p. 44.)

Coniocybe.	Chaenotheca.
Calicium.	Acolium.

SUBORDER GRAPHIDINEAE.

The thallus is crustose in all of ours, and the algal symbiont is *Chroolepus*, except in some *Arthonias*, where *Cystococcus* may occur instead. The fungal symbionts belong to the suborders *Stictidiaceae*, *Hysterineae*, and *Patellariaceae*. The apothecia are elongated and often branched, variously irregular, or rarely rounded. The fruticose *Roccelliaceae*, not represented in our flora, probably place the suborder as a whole above *Coniocarpineae*.

FAMILY GRAPHIDACEAE (p. 52.)

Opegrapha.	Arthonia.
Graphis.	Arthothelium.

SUBORDER DISCOCARPINEAE.

The apothecia are commonly disk or cup-shaped, though a few forms show fruits nearly closed. The exciple is proper or thalloid or sometimes double when the thalloid exciple surrounds the proper exciple. The thallus varies greatly, showing crustose, foliose, and fruticose forms as well as various intermediate conditions. Likewise, all the forms of algal symbionts at all common in lichen thalli may be looked for in the suborder. The fungal symbionts are not easily traceable in most instances to their ancestral forms, but they belong, at least mainly, to the *Patellariaceae*. Nearly all of our conspicuous lichens belong to the present suborder.

FAMILY LECANACTIDACEAE (p. 59.)

Melaspilea.	Lecanactis.
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FAMILY GYALECTACEAE (p. 61.)

Gyalecta.	Secoliga.
	Conotrema.

FAMILY LECIDEACEAE (p. 64.)

Biatorella.	Bilimbia.
Lecidea.	Bacidia.
Megalospora.	Buellia.
Biatorina.	Rhizocarpon.

FAMILY PSORACEAE (p. 101.)

Psora.	Toninia.
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FAMILY BAEOMYCETACEAE (p. 105.)

Baeomyces.	Icmadophila.
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FAMILY CLADONIACEAE (p. 106.)

Cladonia.

FAMILY STEREOCAULACEAE (p. 129.)

Stereocaulon.	Pilophorus.
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FAMILY COLLEMACEAE (p. 132.)

Synechoblastus.	Collema.
	Leptogium.

FAMILY PYRENOPSISACEAE (p. 142.)

Pyrenopsis.	Omphalaria.
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FAMILY EPHEBACEAE (p. 146.)

Ephebe.

FAMILY PANNARIACEAE (p. 147.)

Endocarpiscum.	Heppia.
	Pannaria.

FAMILY STICTACEAE (p. 153.)

Sticta.

FAMILY PELTIGERACEAE (p. 157.)

Solorina.	Peltigera.
	Nephroma.

FAMILY GYROPHORACEAE (p. 166.)

Gyrophora.	Umbilicaria.
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FAMILY LECANORACEAE (p. 169.)

Acarospora.	Lecanora.
	Haematomma.

FAMILY PERTUSARIACEAE (p. 186.)

Pertusaria.

FAMILY PARMELIACEAE (p. 190.)

Parmelia.	Ramalina.
Cetraria.	Alectoria.
Evernia.	Usnea.

FAMILY TELOSCHISTACEAE (p. 211).

Placodium. Teloschistes.

FAMILY PHYSCIACEAE (p. 219).

Rinodina. Pyxine.
Phycia. Urceolaria.

SUBORDER PYRENOCARPINEAE.

The thallus varies from undifferentiated and mainly hypophloëodal or hypolithic crustose conditions to well developed foliose or fruticose forms. The algal symbiont is either *Chroolepus* or *Pleurococcus*. The fungal symbionts belong to the Sphaeriaceae or to closely related fungi. The apothecia are furnished with a perithecium, which entirely incloses the hymenium, except for the apical ostiole, and are more or less immersed in the thallus or the substratum. Within the perithecium is found the amphithecium, a less heavy layer. Or the perithecium may be almost entirely wanting, when the amphithecium alone is seen about the hymenium.

FAMILY VERRUCARIACEAE (p. 232).

Verrucaria.

FAMILY PYRENULACEAE (p. 235).

Sagedia. Arthopyrenia.
Pyrenula.

FAMILY DERMATOCARPACEAE (p. 241).

Thelocarpon. Dermatocarpon.

FAMILY ENDOCARPACEAE (p. 244).

Endocarpon. Staurothlele.

FAMILY LEPRARIACEAE (p. 247).

Amphiloma.

ARTIFICIAL KEY TO THE GENERA.

Thallus foliose (or squamulose).

Thallus of the modified foliose form known as squamulose.

Algal cells blue-green (probably *Polycoccus*); spores
hyaline or pale, simple to 4-celled..... PANNARIA (p. 150).Algal cells bright green (*Cystococcus*).

Spores simple, hyaline, ellipsoid..... PSORA (p. 101).

Spores hyaline, ellipsoid, 4 to 8-celled..... TONINIA (p. 104).

Thallus plainly foliose.

Algal cells bright green (*Cystococcus* or *Pleurococcus*).Spores simple, hyaline (sometimes slightly colored in *Gyrophora*).

Thallus attached by an umbilicus.

Apothecia scattered and immersed..... DERMATOCARPON (p. 242).

Apothecia clustered on a very short pedicel. GYROPHORA (p. 166).

Thallus not attached by an umbilicus.

Thallus small, closely adnate (scarcely plainly foliose)..... Higher species of LECANORA (p. 171).

- Thallus usually larger, less closely attached.
- Spores commonly medium-sized and ellipsoid; thallus usually large and rather closely attached *PARMELIA* (p. 190).
- Spores commonly smaller, short or sub-spherical; thallus usually smaller and less closely attached..... *CETRARIA* (p. 199).
- Spores not simple.
- Spores 2-celled.
- Spores hyaline, the cells polar; thallus usually yellowish, varying toward gray..... *TELOSCHISTES* (p. 217).
- Spores brown, the cells not polar.
- Thalloid exciple usually of the color of the thallus, usually sea-green or brownish.. *PHYSCIA* (p. 224).
- Thalloid exciple blackening, thus becoming indistinct, except in sections; thallus sea-green *PYXINE* (p. 230).
- Spores muriform, brown or hyaline.
- Apothecia clustered on the large thallus..... *UMBILICARIA* (p. 168).
- Apothecia not clustered, immersed in the minute, not plainly foliose thallus..... *ENDOCARPON* (p. 244).
- Algal cells nearly always blue green (*Nostoc*, *Gloeocapsa*, *Polycoccus*, *Dactylococcus*, etc.).
- Algal symbiont *Nostoc*, showing the pseudocysts and heterocysts plainly; thallus becoming gelatinous when wet.
- Thallus having a cortex of a single layer of cells.. *LEPTOGIUM* (p. 139).
- Thallus without a cortex.
- Spores hyaline, several-celled, not muriform... *SYNECHOBLASTUS* (p. 133).
- Spores hyaline, more or less muriform at maturity..... *COLLEMA* (p. 136).
- Algal symbiont not *Nostoc*.
- Algal cells in groups (*Gloeocapsa*?) in the dark-colored thalli on rocks..... *OMPHALARIA* (p. 144).
- Algal cells in chains, the chains not easily discernible (*Polycoccus* or *Dactylococcus*, usually) in the commonly large thalli.
- Thallus cellular throughout, closely adnate... *HEPPIA* (p. 149).
- Thallus not cellular throughout.
- Thallus having cyphellæ or whitish spots on the lower side; spores 2 to 4-celled, hyaline or brown..... *STICTA* (p. 154).
- Thallus without cyphellæ or whitish spots below.
- Thallus with cellular cortex above and below.
- Spores simple, minute, numerous in each ascus; thallus small..... *ENDOCARPISCUM* (p. 148).
- Spores not minute, not numerous in each ascus.
- Spores simple, hyaline, ellipsoid; thallus small, of various colors.
- Some species of *PANNARIA* (p. 150).

- Spores brown or brownish, commonly 4-celled; thallus larger and usually brownish..... NEPHROMA (p. 164).
- Thallus without well-developed lower cortex.
- Thallus large, no lower cortex; spores long and slender, with 4 to 8 or more cells..... PELTIGERA (p. 159).
- Thallus sometimes showing a rudimentary lower cortex, smaller; spores commonly 2-celled..... SOLORINA (p. 158).
- Thallus wholly or partly fruticose or crustose.
- Thallus fruticose, or else 2-fold, in part fruticose and in part foliose or crustose.
- Thallus 2-fold, consisting of a fruticose portion and a foliose (squamulose) or a crustose portion.
- Thallus consisting of a fruticose portion (the podetium) and a foliose (squamulose) or rarely crustose portion, the latter frequently evanescent..... CLADONIA (p. 107).
- Thallus consisting of a fruticose portion (the stipe, strictly part of the fruit) and a crustose portion.
- Stipes well developed, very small and rarely branched.
- Spores spherical or subspherical.
- Spores colorless or only slightly colored..... CONIOCYBE (p. 45).
- Spores brown or brownish..... CHAENOTHECA (p. 48).
- Spores oblong or ellipsoid.
- Spores simple and hyaline..... BAEOMYCES (p. 105).
- Spores brown and usually 2-celled..... CALICIUM (p. 45).
- Stipes very short and seldom evident.
- Spores hyaline, 2 to 4-celled..... ICMADOPHILA (p. 106).
- Spores brown and 2-celled..... ACOLIUM (p. 51).
- Thallus consisting of a fruticose portion only, or (Pilophorus and Stereocaulon) also of an evanescent, horizontal portion rarely seen.
- Podetia present, clothed more or less with phyllocladia.
- Thallus small and rarely branched..... PILOPHORUS (p. 132).
- Thallus larger and much branched..... STEREOCAULON (p. 130).
- Podetia wanting.
- Algal symbiont, Sirospion, determining the form of the thallus and giving it a dark color EPHEBE (p. 146).
- Algal symbiont, Cystococcus, not determining the form or color.
- Branches cylindrical or compressed-cylindrical.
- Grayish to sea-green, or rarely reddish, rarely angular..... USNEA (p. 207).
- Commonly brownish to blackish, rarely sea-green..... ALECTORIA (p. 206).

Branches flattened.

Spores hyaline, simple.

Thallus sea-green, not conspicuously channeled..... EVERNIA (p. 202).

Thallus pale or darker brown, conspicuously channeled..... One species of CETRARIA (p. 199).

Spores 2-celled.

Spores brown; thallus usually sea-green.

One species of PHYSCIA (p. 224).

Spores hyaline.

Cells of spores proximate; thallus usually sea-green or grayish..... RAMALINA (p. 203).

Cells of spores polar; thallus more or less yellowish..... TELOSCHISTES (p. 217).

Thallus crustose.

Apothecia unknown; thallus rudimentary and sessile.....

AMPHILOMA (p. 247).

Apothecia well known and usually present.

Proper exciple produced into a perithecium; thal-
loid exciple absent or uncertain.Apothecia immersed in the thallus and the peri-
thecium poorly developed or not discernible,
being usually replaced by an amphithecium.Apothecia usually grouped in verrucæ; spores
very large..... PERTUSARIA (p. 187).

Apothecia occurring singly.

Spores simple, minute and many in each as-
cus, hyaline; thallus strictly crustose,
granular, greenish.....

THELOCARPON (p. 241).

Spores muriform, hyaline or brown, large and
few in each ascus; thallus showing a cor-
tex in section.....

ENDOCARPON (p. 244).

Apothecia partially or rarely entirely immersed
in the substratum or the thallus, but the peri-
thecium always well developed.

Spores hyaline, never muriform.

Spores simple; thallus well developed, ver-
rucose or areolate, the apothecia not
often completely immersed.....

VERRUCARIA (p. 233).

Spores not simple.

Spores 2 to several-celled, ellipsoid to lin-
ear-oblong; thallus and apothecia
partly or mainly in the substratum...

ARTHOPYRENIA (p. 236).

Spores 4 to several-celled, fusiform to acicu-
lar; thallus and apothecia as in Artho-
pyrenia.....

SAGEDIA (p. 235).

Spores brown or muriform, or both.

Spores brown, 2 to several-celled; thallus and
apothecia partly or mainly in the sub-
stratum.....

PYRENULA (p. 238).

Spores muriform, brown or rarely hyaline;
thallus conspicuous on the substratum
and the apothecia immersed more or less
in it.....

STAUROTHELE (p. 246).

- Spores with 2 or more cells.
 Spores 2-celled, thallus commonly granular or verrucose..... BIATORINA (p. 82).
 and our one species of MELASPILEA (p. 59).
- Spores more than 2-celled.
 Spores 4 to 9-celled, fusiform or finger-shaped; thallus granular or verrucose..... BILIMBIA (p. 84).
 and our one species of LECANACTIS (p. 60).^a
- Spores 4 to 16-celled, very slender (acicular); thallus granulose, chinky, subareolate or subsquamulose.... BACIDIA (p. 83).
- Spores commonly brown.
 Spores 2-celled, or rarely 4-celled; thallus granulose, verrucose, or areolate..... BUELLIA (p. 92).
 Spores at first 4-celled, passing into muriform, rarely hyaline; thallus verrucose, areolate, or rarely subsquamulose..... RHIZOCARPON (p. 97).
 and our last species of SECOLIGA (p. 62).
- Apothecia commonly more or less elongated or irregular.
 Apothecia elongated and sometimes branched.
 Apothecia superficial or partly immersed, oblong to linear, rarely rounded, seldom branched..... OPEGRAPHA (p. 52).
 Apothecia more or less immersed, linear or rarely short, usually curved and frequently more or less branched..... GRAPHIS (p. 54).
- Apothecia commonly more or less irregular.
 Spores medium-sized, hyaline or brownish, with 4 or rarely more cells..... ARTHONIA (p. 55).
 Spores large, muriform, hyaline or brownish..... ARTHOTHELIUM (p. 58).

DESCRIPTIONS OF FAMILIES, GENERA, AND SPECIES.^b

Family CALICIACEAE.

The character which most readily distinguishes the Caliciaceae is the gelatinization and dissolution of the upper portion of the asci before the spores are mature. The

^a See also the first species of *Secoliga* (p. 62).

^b The following trees are cited as substrata of lichen species:

Balsam. The balsam fir, *Abies balsamea* Mill.

Birch. The canoe or paper birch, *Betula papyrifera* Marsh.

Cedar. The white cedar or arbor-vitæ, *Thuja occidentalis* L.

Elm. The American white elm, *Ulmus americana* L. and perhaps the slippery or red elm, *Ulmus fulva* Michx.

Oak. *Quercus macrocarpa* Michx., *Q. alba* L., *Q. rubra* L., *Q. velutina* Lam., *Q. coccinea* Moench.

Pine. The white pine, *Pinus strobus* L., the red or pitch pine, *P. resinosa* Ait., and the gray or jack pine, *P. divaricata* Du Mont de Cours.

Poplar. *Populus balsamifera* L., *P. deltoides* Marsh., *P. grandidentata* Michx., *P. tremuloides* Michx.

Spruce. The black spruce, *Picea mariana* (Mill.) B. S. P., and the white spruce, *P. canadensis* (Mill.) B. S. P.

Tamarack. The larch, *Larix americana* Michx.

spores escape thus before they have reached their full size and while yet colorless, and are doubtless nourished, in part at least, by the substance derived from the dissolved walls of the asci. The stipes are well developed except in the single genus *Acolium*, where they are very short.

The horizontal thallus is crustose and varies from rudimentary and inconspicuous to better developed and even areolate conditions, as in our common *Acolium tigillare*. The algal symbiont is *Cystococcus*, except in *Coniocybe*, where *Chroolepus* may occur instead. The fruticose stipe is strictly a part of the fruit.

The four genera of our flora placed in the family are certainly very closely related, forming a very distinct group of lichens. The plants are all minute and difficult to detect. They are certainly among the lowest lichens, and many of the species have been placed among other fungi by some authors.

The work on the genera *Calicium* and *Chaenotheca* in Minnesota has added conspicuously to known distribution.

CONIOCYBE Ach. Vet. Akad. Handl. 1816: 283. *pl. 8. f. 16.* 1816.

The horizontal thallus is crustose and may form a smooth film over the substratum or become more or less scurfy. In some of the species it is more or less evanescent, while in the more persistent and well developed forms it resembles the thalli of the *Chaenothecas* and is nearly as well developed. There is no cellular cortex, but the protective hyphal layer is well developed in some of the species. The algal symbiont Dr. Albert Schneider finds to be a form of *Chroolepus*, at least in certain plants examined. The thallus is more or less widely spread over the substratum as a continuous or more or less broken layer. The stipe is similar to that of *Calicium*.

The apothecia are similar in form to those of *Calicium*, but are usually ashy or yellowish, though brownish black apothecia exist in at least one species. The exciple, at least in our two American species, is light in color, and though it may inclose the apothecium in very young stages, tends to disappear, leaving the apothecium more or less biatoroid. The spores are simple, spherical, and hyaline or slightly colored.

Of the other members of the family, *Coniocybe* is plainly most closely related to *Chaenotheca*, both as to spore and thallus characters.

A single species occurs in the State.

Type species *Coniocybe brachypoda* Sch. op. cit. 287.

1. ***Coniocybe pallida*** (Pers.) Fr. Sched. Crit. Lich. Exsicc. Suec. 3. 1826.

Calicium pallidum Pers. Ann. Bot. Usteri 7: 20. 1794.

Thallus a thin, whitish crust, frequently spread over the substratum in irregular areas, but sometimes disappearing; stipes slender, about 1 to 2 mm. in length, whitish or yellowish, often brownish toward the top; apothecia minute or small, 0.15 to 0.3 mm. in diameter, the disk brownish and commonly convex, the exciple of the same color or lighter-pruinose, or in younger spheroidal apothecia both disk and exciple yellowish or whitish, or even white-pruinose; hypothecium pale or pale brownish; hymenium pale below but usually brownish above; paraphyses usually branched and neither enlarged nor colored toward the apex; asci cylindrical, soon dissolving; spores simple, spherical, hyaline, 3 to 7 μ in diameter.

Generally distributed over the State. In crevices on bark of old, rough-barked, deciduous trees.

Elsewhere in North America in New England, Illinois, and Iowa. Also in Europe.

CALICIUM Pers. Ann. Bot. Usteri 7: 20. 1794.

The horizontal thallus is crustose, but is rather inconspicuous, scarcely reaching anything more highly differentiated than a thin and minutely granulose condition, and is frequently very evanescent. It may be entirely wanting in parasitic species, and in these, as well as in some of the nonparasitic species, algal cells may be entirely

wanting, at least in the later stages of the life cycle. The forms that are devoid of the algal cells during more or less of the life period are frequently referred to other fungi, as are also forms of *Opegrapha* and certain parasitic species from other genera. The stipe is commonly well developed and is dark in color and quite slender. The algal symbiont is *Cystococcus*.

The apothecia are variously top-shaped, lentiform, or subspherical, and are borne at the top of the well-developed stipes. The exciple is dark in color and frequently, in the early development of the apothecium, almost incloses the then punctiform disk, when the apothecium forms essentially a perithecium. The disk is quite commonly more or less convex until after the spore masses are shed, when it usually becomes flat or even concave. The paraphyses are usually much branched and without apical color or thickening. Both simple and 2-celled spores occur in the genus, and even 4-celled and muriform spores are admitted by Tuckerman. In color the spores vary from a pale brown to a blackish brown.

The close relationship of *Calicium* to *Chaenotheca* and *Coniocybe* is apparent enough, and the present genus is also closely related to *Acolium*.

Seven species and subspecies occur in the State. On trees and old wood.

Type species *Calicium viride* Pers. loc. cit.

KEY TO THE SPECIES.

Parasitic on other lichens or on fungi; no thallus visible.

Stipes very short and stout; on *Pertusaria communis*..... 6. *C. turbinatum*.

Stipes longer and more slender than the last; on *Coriobolus versicolor*..... 7. *C. polyporaenum*.

Not parasitic on lichens or other fungi; thallus visible, whitish, often evanescent.

Stipes slender.

Apothecia top-shaped or lenticular..... 1. *C. parietinum*.

Apothecia usually subglobose..... 5. *C. pusillum*.

Stipes stouter.

Stipes very short..... 4. *C. curtum*.

Stipes not so short.

Disk often and the exciple usually white-pruinose. 3. *C. quercinum*.

Disk and exciple not pruinose..... 2. *C. trachelinum*.

1. *Calicium parietinum* Ach. Vet. Akad. Handl. 1816: 260. 1816.

Thallus very rudimentary, evanescent, when present indicated by whitish patches upon or in the substratum; stipes dark brown to black in color, 0.7 to 2 mm. in length; apothecia small or minute, 0.1 to 0.35 mm. across, top-shaped or lenticular, or in younger stages subspherical, the disk finally becoming convex, or flat with the dispersion of the spores, dark brown, the exciple dark brown and frequently ashy-pruinose below; hypothecium dark brown; hymenium pale below and brownish above; paraphyses frequently branched; asci cylindrical; spores simple, ellipsoid, pale blackish brown, 6 to 11 μ long and 3 to 6 μ wide.

Occurring throughout the State. On dead wood at some distance above the damp ground.

Distributed throughout North America. Known also in Europe.

2. *Calicium trachelinum* Ach. Lich. Univ. 237. 1810.

Calicium claviculare trachelinum Ach. Meth. Lich. 91. 1803.

Thallus ashy, thin, and granulose, commonly evanescent; stipes black or brownish black, rather longer and stouter than in the last; apothecia also rather larger than in the last, top-shaped or subglobose at maturity, the disk becoming brown and strongly convex before the spores are dispersed, the exciple dark in section and microscop-

ically reddish brown below; hypothecium dark brown; hymenium pale below and darker above; paraphyses distinct and commonly branched; asci cylindrical; spores brown or blackish brown, 2-celled, ellipsoid, commonly somewhat constricted at the septum, 7 to 12 μ long and 3 to 5 μ wide.

Throughout northwestern Minnesota. On dead cedar and tamarack wood in swamps.

Elsewhere in North America in New England, the Carolinas, Illinois, and Missouri. Known also in Europe and South America.

3. *Calicium quercinum* Pers. Tent. Disp. Fung. 59. 1797.

Thallus white or ashy, smooth, granulose or even scurfy, more or less evanescent; stipes black or brownish black, rather stout, and 0.6 to 1.8 mm. in length; apothecia small, 0.2 to 0.4 mm. in diameter, top-shaped or lentiform at maturity, the disk blackish brown or whitish-pruinose, nearly flat or quite convex, the exciple of the same color, but usually whitish-pruinose; hypothecium dark brown; hymenium pale below and brown above; paraphyses freely branching; asci irregularly clavate or cylindrical; spores brown or blackish brown, ellipsoid, 2-celled, 5 to 9 μ long and 3 to 5 μ wide, in some of ours referred here partly simple.

The plant referred here is common enough in northern Minnesota, and has been collected as far south as Granite Falls, but most of the material is doubtful and the thallus very scanty or entirely absent. Usually on dead wood. The subspecies *lentibulare* of the preliminary reports belongs partly above and in part with the next.

Elsewhere in North America in New England and Ohio. Found also in Europe.

4. *Calicium curtum* Borr. & Turn. Lich. Brit. 148. 1839.

Thallus a very thin granulose crust, ashy in color and becoming scarcely visible or entirely disappearing; stipes rather stout and in ours very short, scarcely exceeding 0.2 to 0.5 mm. in length, black; apothecia black throughout, like the last in form and size, but the black disk and exciple never pruinose in ours, the disk commonly flat; hypothecium dark brown; hymenium pale below and brown above; paraphyses commonly branched; asci cylindrical; spores blackish brown, 2-celled, ellipsoid, 7 to 12 μ long and 4 to 6 μ wide.

Nylander says that the margin of the exciple is white-pruinose. Ours in this respect is nearer the subspecies *lentibulare*, which is excluded from this volume (see under *C. quercinum*).

Collected at several places in northwestern Minnesota. On coniferous trees or the dead wood.

Elsewhere in North America in New England. Also found in Europe, South America, and New Zealand.

5. *Calicium pusillum* (Ach.) Floerke, Deutsch. Lich. 10: 6. 1821.

Calicium sphaerocephalum pusillum Ach. Meth. Lich. 92. 1803.

Thallus evanescent, but rarely to be made out as a whitish or ashy coloration upon the substratum; stipes slender and rather short, 0.3 to 0.6 mm. in length, black; apothecia minute, 0.1 to 0.2 mm. in diameter, subglobose or top-shaped lentiform, the disk brownish black and more or less convex, the exciple black or brownish black; hypothecium brown; hymenium pale below and brown above; paraphyses commonly branching freely; asci cylindrical; spores brown or blackish brown, ellipsoid, 2-celled, 6 to 10 μ long and 2 to 5 μ wide.

Collected in northern Minnesota at Henning, Rainy Lake City, and Tower. On dead cedars and tamaracks in swamps.

Elsewhere in North America in California, Quebec, Newfoundland, and Vancouver Island. Found also in Europe and Africa.

6. *Calicium turbinatum* Pers. Tent. Disp. Fung. 59. 1797.

Parasitic and no thallus distinguishable except that of the host; stipes very short, stout and black, the apothecia being often almost or perhaps rarely quite sessile upon the thallus of the host; apothecia small, 0.2 to 0.4 mm. in diameter, at maturity globose top-shaped, the disk in the mature and open apothecia flat and dull black, the exciple black, often with a lighter margin; hypothecium dark brown or brownish black; hymenium pale below and brown above; paraphyses simple or branched, commonly distinct; spores brown or blackish brown, simple, subglobose or rarely short-ellipsoid, 4 to 7 μ in diameter.

Throughout the cedar swamp areas of northern Minnesota. On *Pertusaria communis* on cedars in swamps.

Elsewhere in North America at New Bedford, Massachusetts, and in Canada, Alaska, and Newfoundland. Also in Europe and Africa.

7. *Calicium polyporaëum* Nyl. Flora 58: 7. 1875.

PLATE 1, A.

Parasitic and no thallus distinguishable, at least in material examined; stipes and apothecia very similar to those of *Calicium parietinum*, but the present plant as a whole rather smaller, with the apothecia rather more narrowly top-shaped and the disk more commonly flat; hypothecium brown; hymenium pale below and brownish to dark brown above; paraphyses frequently branched; asci cylindrical; spores simple, brown, oblong-cylindrical, 9 to 18 μ long and 3 to 4.5 μ wide. Nylander says, "Sporae magis cylindraceo-oblongae quam in *C. parietino*, quo caractere constante *C. polyporaëum* sit distinguendum."

Occurring throughout the northern one-third of the State. On *Coriolus versicolor* and closely related fungi.

A North American plant known elsewhere at New Bedford, Massachusetts, and in a few localities in Iowa.

EXPLANATION OF PLATE 1.—A, Plants of *Calicium polyporaëum* on *Coriolus versicolor*. Apothecia on stipes. B, Plants of *Opegrapha varia* on white cedar, showing the apothecia and the whitish coloration due to the thallus. A enlarged 3 diameters; B, 1 $\frac{1}{2}$ diameters.

CHAENOTHECA Th. Fr. Gen. Het. Eur. 102. 1861.

The thallus is as a whole much better developed than in *Calicium*, and is quite conspicuous and more like that of the species of *Acolium*, at least in most of our species. In one of ours in which the stipe is quite short the external resemblance between the two genera becomes quite marked. In the better developed species the thallus becomes a scattered or subcontinuous verrucose or even subareolate crust. In others it is granular or mealy. The algal symbiont is as usual in the family. The stipe is quite similar to that of the species of *Calicium*.

The apothecia are very similar to those of *Calicium*s, but the spores are uniformly simple and spherical or subspherical. They are brown or brownish.

The relationships have been sufficiently discussed above and in the descriptions of other genera of the family. The species were included with *Calicium* in the preliminary reports.

Eight species and subspecies are known in Minnesota, all occurring on living or dead coniferous wood in the northern portion of the State.

Type species *Chaenotheca chrysocephala* (Turn.) Th. Fr. loc. cit.

KEY TO THE SPECIES.

Thallus lemon-yellow to yellowish green.

Stipes rather short 1. *C. chrysocephala*.

Stipes longer and pruinose 1a. *C. chrysocephala filaris*.



A. CALICIUM POLYPORAEUM NYL.



B. OPEGRAPHA VARIA PERS.

Thallus ashy to ashy greenish or ashy yellow.

Thallus well developed, plainly granular.

Granules squamiform..... 2. *C. phaeocephala*.

Granules smaller, not so plainly squamiform..... 3. *C. trichialis*.

Thallus not well developed, rarely granular.

Thallus frequently disappearing.

Thallus evanescent and seldom seen..... 4. *C. brunneola*.

Thallus not so readily disappearing..... 2a. *C. phaeocephala trabinella*.

Thallus seldom or never disappearing.

Thallus thin and scurfy..... 3a. *C. trichialis stemonea*.

Thallus better developed and granulose..... 3b. *C. trichialis cinerea*.

1. *Chaenotheca chrysocephala* (Turn.) Th. Fr. Gen. Het. Eur. 102. 1861.

Lichen chrysocephalus Turn. Trans. Linn. Soc. Lond. 7: 88. pl. 8. f. 1. 1804.

Thallus lemon-yellow or yellowish green, granulose or verrucose, the granules or verrucæ varying from conglomerate to scattered; stipes rather short, 0.35 to 1.2 mm. in length, black or dark brown, sometimes slightly greenish-pruinose, longer in some other North American material; apothecia minute, 0.1 to 0.25 mm. across, top-shaped or younger conditions spheroidal, at maturity the disk dark brown and flat or slightly convex, the exciple blackish brown, and yellowish or greenish-pruinose below as is often the top of young and spheroidal apothecia; hypothecium dark brown; hymenium pale to pale brownish; paraphyses often more or less coherent, simple and neither thickened nor colored toward the apex; asci cylindrical; spores more or less brown, 3 to 6 μ in diameter.

Distributed throughout the pineries of northern Minnesota. On living and dead coniferous wood, especially pine wood and bark.

Elsewhere in North America at New Bedford, Massachusetts. Known also in Europe.

Calicium chrysocephalum of the preliminary reports.

1a. *Chaenotheca chrysocephala filaris* (Ach.) Fink.

Calicium chrysocephalum filare Ach. Lich. Univ. 239. 1810.

Thallus scattered and granular, yellowish; both stipe and apothecium rather elongated and slightly pruinose.

Collected at Tofte. On dead wood.

Not known elsewhere in North America. Found also in Europe.

Calicium chrysocephalum filare of the preliminary reports.

2. *Chaenotheca phaeocephala* (Turn.) Th. Fr. Nov. Act. Soc. Sci. Ups. III. 3: 351. 1861.

Lichen phaeocephalus Turn. Trans. Linn. Soc. Lond. 8: 260. pl. 6. f. 1. 1807.

Thallus ashy or dirty-yellow, frequently quite thick, composed of small scattered or clustered squamiform granules, which may even show more or less crenate margins; stipes longer than in the last, 0.4 to 2.5 mm. in length, black or brownish black, rarely paler or quite pale toward the base, sometimes thinly and yellowish green pruinose, especially toward the top; apothecia somewhat larger than in the last, reaching 0.3 mm. in diameter, the form of young and mature ones also as in the last, the disk at maturity convex and dark brown, the exciple dark brown and yellowish green-pruinose or becoming naked with age; hypothecium dark brown; hymenium pale below and brownish above; paraphyses simple or branched, without apical color or thickening; asci cylindrical; spores brown or brownish, spherical or spheroidal, 3 to 5 μ in diameter or one dimension reaching 6 μ .

Collected along the northern boundary at Beaudette and Emo. On cedars in swamps.

Elsewhere in North America in British America and New England. Also in Europe.

Calicium phaeocephalum of the preliminary reports.

2a. *Chaenotheca phaeocephala trabinella* (Ach.) Fink.

Calicium xylonellum trabinellum Ach. Meth. Lich. 93. 1803.

Thallus of smaller and scattered granules and often disappearing; stipes commonly longer.

With the last and perhaps more common.

Not known elsewhere in North America. Found also in Europe.

Calicium phaeocephalum trabinellum of the preliminary reports; *Calicium trabinellum* of the reports is likewise the same.

3. *Chaenotheca trichialis* (Ach.) Th. Fr. Nov. Act. Soc. Sci. Ups. III. 3: 351. 1861.

Calicium trichiale Ach. Lich. Univ. 243. 1810.

Thallus from ashy varying toward yellowish green or sea-green, squamulose-granular as in the last, but the granules smaller and usually more scattered; stipes black or blackish brown, 0.3 to 2 mm. in length; apothecia at maturity with a very convex disk, giving the whole structure a globose-lenticular form, of about the same size as in the last, both the disk and the exciple dark brown, or the exciple ashy-pruinose below; hypothecium dark brown; hymenium pale below and brownish above; paraphyses coherent and indistinct in the material examined; asci cylindrical; spores spherical, brown or brownish, 2.5 to 5 μ in diameter.

Collected in northeastern Minnesota at Rose Lake, Snowbank Lake, and at Beaver Bay. On coniferous wood.

Elsewhere in North America at New Bedford, Massachusetts, and in Quebec and Ontario. Known also in Europe.

Calicium trichiale of the preliminary reports.

3a. *Chaenotheca trichialis stemonea* (Ach.) Fink.

Calicium trichiale stemoneum Ach. Lich. Univ. 243. 1810.

Thallus thin and scurfy, yellowish or yellowish green, otherwise as above.

Once collected, at Ely. On pines.

Not known elsewhere in North America. Found also in Europe.

Calicium trichiale stemoneum of the preliminary reports.

3b. *Chaenotheca trichialis cinerea* (Pers.) Fink.

Calicium cinereum Pers. Icon. Descr. Fung. 58. 1800.

Thallus granulose; stipes commonly brown and apothecia of the same color or ashy-pruinose below, as the stipes may also be; spores perhaps larger.

The most common form of the species, no doubt occurring throughout the coniferous woods in northern Minnesota. On living and dead coniferous wood.

Not known elsewhere in North America. Found also in Europe.

Calicium trichiale cinereum of the preliminary reports.

4. *Chaenotheca brunneola* (Ach.) Müll. Arg. Mém. Soc. Phys. Hist. Nat. Genève, 16²: 360. 1862.

Calicium brunneolum Ach. Vet. Akad. Handl. 1816: 279. 1816.

Thallus very thin, ashy or greenish, of minute granules, evanescent and seldom seen; stipes very slender and often much elongated, becoming 5 mm. in length, black; apothecia as those of the last species above as to form, color, and rarely as to pruinose condition; hypothecium brownish black; hymenium pale below and brownish above; paraphyses distinct and frequently branched in the material examined; asci cylindrical; spores spherical or spheroidal, 2.5 to 4 μ in diameter, the longer dimension

reaching 5μ . Considered by Nylander to be a subspecies of the last, and certainly very near.

Collected in northeastern Minnesota at Two Harbors, Ely and about Snowbank Lake. On decorticated coniferous wood.

New Bedford, Massachusetts, is the only other North American locality. Known also in Europe.

Calicium brunneolum of the preliminary reports.

ACOLIUM S. F. Gray, Nat. Arr. Brit. Pl. 1: 482. 1821.

The thallus is crustose and verrucose, or more commonly more or less distinctly areolate, with the areoles usually forming a continuous crust. There is no cellular cortex and no algal nor medullary layers, yet the thallus is rather thick and much better developed than in either *Calicium* or *Coniocybe*, and more like that of *Chaenotheca*. The thallus seldom or never becomes inconspicuous or disappears, except in a few parasitic species, from which it seems to be entirely absent. The algal symbiont is the form of *Cystococcus* usually found in members of the present family.

The apothecia are borne upon a very short stipe, and both stipe and apothecium are frequently embedded in the thallus, so that there seems to be simply the immersed apothecia, the peculiar structure in such instances only appearing in vertical sections through stipe and apothecium. In all of the species is found the dark proper exciple, and in those having the stipe and apothecium immersed in the thallus it is usual to think of the surrounding thallus layer as a thalloid exciple. The disk is more or less concave, even reaching cup-shaped conditions. Both simple and 2-celled spores are found in plants commonly admitted to the genus, and not infrequently the whole range of forms from the simple spore to the muriform condition is included in the one genus. This mass of forms is in need of careful revision, but our flora presents no difficulty in this regard, as we have but two species, these with the usual 2-celled brown spores. The asci dissolve while the spores are quite immature.

The close relationship of the present genus to *Chaenotheca*, *Calicium*, and *Coniocybe* is apparent enough in species of *Acolium*, having the short stipe exposed above the thallus, and is just as apparent in such species as ours when studied in section.

Two species are found in Minnesota. On old pine boards, posts, and trees.

Type species *Acolium tigillare* (Ach.) S. F. Gray, loc. cit.

KEY TO THE SPECIES.

Stipes very short and apothecia immersed..... 1. *A. tigillare*.
Stipes longer and apothecia sessile or slightly elevated..... 2. *A. lucidum*.

1. ***Acolium tigillare*** (Ach.) S. F. Gray, Nat. Arr. Brit. Pl. 1: 482. 1821.

Lichen tigillaris Ach. Lich. Suec. 67. 1798.

Thallus yellowish green or lemon-yellow, crustose, and usually quite prominent, chinky and soon becoming areolate, or rarely granular, commonly widely spread over the substratum as a continuous or more or less broken layer; apothecia small, 0.3 to 0.6 mm. in diameter, on very short stipes, both apothecia and stipes being immersed in the thallus in areolate thalli, one or more apothecia in each areole, or rarely more or less superficial, the disk dull black and flat or somewhat concave, the proper exciple black; hypothecium dark brown; hymenium pale or slightly colored; paraphyses rather short and slender and commonly simple, with scarcely enlarged or colored apex; asci long, cylindrical, soon dissolving; spores blackish brown, 2-celled, constricted at the septum, 12 to 20 μ long and 7 to 10 μ wide.

Widely distributed in the State, and to be looked for wherever boards or posts of pine fences have stood long enough for the plant to become established.

Throughout the eastern portion of North America from the Gulf of Mexico to the Arctic Ocean. Known also in Europe.

2. *Acolium lucidum* (Th. Fr.) Fink.

Trachylia lucida Th. Fr. Öfv. Vet. Akad. Förh. 12: 18. 1855.

Thallus crustose, verrucose, scarcely reaching an areolate condition, the verrucæ usually more or less scattered upon the substratum, but sometimes forming a continuous crust over small areas of the substratum, lemon-yellow or yellowish green; apothecia of about the same size as those of the last, but on somewhat longer stipes, so that the apothecium appears to be sessile upon the thallus or rarely elevated sufficiently so that the stipe may be seen without sectioning, the disk flat and at first bluish green pruinose, the exciple black and prominent; hypothecium dark brown; hymenium pale and frequently brownish above; paraphyses coherent and indistinct in ours examined; asci cylindrical or irregularly cylindrico-clavate; spores brown, 2-celled, ellipsoid, 6 to 9 μ long and 3 to 4 μ wide.

In northern Minnesota. On pines and other conifers and on dead wood.

Not known elsewhere in North America. Also in Europe.

Calicium lucidum of the preliminary reports.

Family GRAPHIDACEAE.

The characters by which the Graphidaceae may most readily be distinguished are those of the apothecia. These organs are commonly elongated or irregular and often branched. Yet a few somewhat rounded apothecia are occasionally seen in some of the species. These remind one of those of *Melaspilea*, but in ours at least the spore characters will always serve to distinguish very easily. Likewise, the clustered apothecia of *Gyrophora* remind one externally of those of some members of the present family, but sections of the apothecia of the *Gyrophoras* reveal a higher type of structure, and the differences in thalli in the Graphidaceae and the *Gyrophoraceae* are easily observable.

The thallus is crustose and usually hypophloeodal in our species, though some species not found in our flora occur on rocks. The structure of the thallus is quite rudimentary, as there is seldom any sign of differentiation. The algal symbiont is *Chroolepus*. The thallus characters are substantially the same as in the *Pyrenulaceae*, but in that family we have the spheroidal apothecia provided with a well-developed perithecium, by which difference the two families are to be distinguished. The spore characters are sufficiently explained in the outline of the families.

It is not at all probable that the genera of the family all had a common origin, and yet both the apothecial and the thallus characters would seem to indicate a close relationship.

The family is mainly southern in distribution, and the number of genera and species found in Minnesota is not large. The plants usually occur on smooth bark. *Graphis scripta* is by far the most common member of the family in Minnesota.

OPEGRAPHA Humb. Fl. Friberg. 57. 1793.

The thallus is crustose and mainly hypophloeodal, forming a smooth crust upon the substratum when the epiphloeodal portion of the thallus is not entirely wanting, devoid of differentiation into layers, and, as usual in such low lichens, the hyphal rhizoids extending some distance into the substratum. The algal symbiont is a form of *Chroolepus*.

The apothecia are linear, oblong, or more or less rounded or irregular, rarely branched, with a usually narrowly furrowed or concave disk, superficial or more or less immersed in the substratum. The proper exciple is black, heavy, and prominent. The spores are 4 or more celled, and fusiform, ellipsoid, or finger-shaped, though some lichenists include in the genus similar lichens having persistently 2-celled spores.

The genus is plainly most closely related to *Graphis*, though its relation to *Arthonia*, *Melaspilea*, and *Lecanactis* is not remote.

Four species and subspecies have been found in Minnesota.

Type species *Opegrapha vulgaris* Humb. loc. cit. This is a synonym for *Graphis scripta*, and the name *Opegrapha* becomes invalid and will need to be changed when all lichen genera have been typified.

KEY TO THE SPECIES.

- Parasitic on other lichens..... 2. *O. quaternella*.
 Not parasitic on other lichens.
 Apothecia lanceolate..... 1. *O. varia*.
 Apothecia not lanceolate.
 Apothecia oblong-ellipsoid..... 1b. *O. varia pulicaris*.
 Apothecia oblong or suborbicular..... 1a. *O. varia notha*.

1. *Opegrapha varia* Pers. Ann. Bot. Usteri 7:30. 1794. PLATE 1, B.

Epiphloeodal portion of the thallus a thin whitish film forming a continuous or more or less scattered layer upon the substratum, or disappearing; apothecia lanceolate, small, 0.2 to 0.4 mm. wide and 0.4 to 1.5 mm. long, adnate or more or less immersed in the substratum, the disk black and usually more or less furrowed, the exciple black and prominent, persistent and heavy; hypothecium blackish brown; hymenium pale below and darker above; paraphyses rarely branched, sometimes more or less coherent, commonly enlarged and darkened toward the apex; asci clavate or cylindrico-clavate; spores hyaline or brownish, 4 to 6-celled, fusiform, 15 to 24 μ long and 5 to 8 μ wide.

Generally distributed in the State. On trees.

Also distributed throughout North America. Known also in Europe and Africa.

EXPLANATION OF PLATE 1. See page 48.

1a. *Opegrapha varia notha* (Ach.) Nyl. Not. Sällsk. Faun. Flor. Fenn. 5: 253. 1861.
Lichen nothus Ach. Lich. Suec. 19. 1798.

This form is distinguished by the oblong or suborbicular apothecia.

Collected at Rose Lake in the northeastern portion of the State. On cedars.

Does not appear in any American lichen lists known to me, though it is credited to our continent by Europeans. Occurs in Europe and Africa.

1b. *Opegrapha varia pulicaris* (Ach.) Nyl. Not. Sällsk. Faun. Flor. Fenn. 5: 253. 1861.

Opegrapha vulvella pulicaris Ach. Lich. Univ. 251. 1810.

Distinguished by the oblong-ellipsoid apothecia with commonly connivent exciple. The apothecia are smaller in ours. Determined by A. Zahlbruckner.

Collected at Granite Falls. On trees. There may well be some doubt as to the worth of these subspecies, but such as they are, they doubtless are to be looked for elsewhere in Minnesota.

Elsewhere in North America in New England, Ohio, Iowa, and Nebraska. In all the grand divisions except South America.

2. *Opegrapha quaternella* Nyl. Flora 68: 449. 1885.

Parasitic and no thallus discernible except that of the host; apothecia irregular in form and usually densely clustered, minute, 0.2 to 0.3 mm. in diameter, irregularly oblong where sufficiently distinct to show form, the exciple black and irregular; hypothecium dark brown; hymenium more or less brown or brownish; paraphyses distinct and rarely branched, commonly enlarged and darker toward the apex; asci clavate; spores 4 in each ascus, hyaline, oblong or oblong-ellipsoid, 16 to 22 μ long and 5 to 7 μ wide.

Collected once at Emo along the northern boundary. On *Peltigera aphthosa*.

A North American lichen known elsewhere at New Bedford, Massachusetts, and at Fayette, Iowa.

GRAPHIS Adans. Fam. Pl. 2: 11. 1763.

The thallus is similar to that of *Opegrapha*, being hypophloeodal in part and devoid of differentiation into layers. A thin epiphloeodal portion usually spreads over the substratum as a film. The algal symbiont is, as usual in the family, similar to that of *Opegrapha*.

The apothecia are linear, usually curved, and not infrequently more or less branched, shorter and even suborbicular forms occurring rather rarely. They may be immersed in the substratum completely or only slightly. The proper exciple is dark and perhaps most commonly black, at least above, and is usually crowned by a portion of the epiphloeodal thallus film, which may be regarded as a thalloid exciple. The disk is closed or narrowly linear and commonly black. The spores are usually composed of 6 or more cells, though 4-celled forms occur, and even muriform-spored lichens are included in the genus by lichenists. In form the spores are commonly oblong-ellipsoid, and the exosporium is often wavy, giving the spore a sort of caterpillar-like form. Both hyaline and more or less brownish spores occur within the genus.

The similarity between *Graphis* and *Opegrapha* is apparent enough, and the present genus seems also to show a somewhat close relationship with such genera as *Conotrema* and *Megalospora*, where we find similar spores and more or less evanescent thalloid exciples surrounding the proper exciples.

Mr. W. W. Calkins has recognized four species within the State, but two of these are plainly the common *Graphis scripta*, and a third perhaps another form of the same species. Ours all occur on trees.

Type species *Lichen scriptus* L. (*Graphis scripta* (L.) Ach.)

Based on *Lichenoides* Dill. Musc. pl. 18. f. 1, 2. 1741, figure 1, being identified in L. Sp. Pl. 1140. 1753.

KEY TO THE SPECIES.

- Epiphloeodal portion of the thallus rather thick, not widely spread..... 1b. *G. scripta serpentina*.
 Epiphloeodal portion of the thallus thin, usually widely spread.
 Apothecia radiately branched or radiately arranged... 2. *G. dendritica*.
 Apothecia not radiately branched nor radiately arranged.
 Apothecia variously curved, sometimes branched. 1. *G. scripta*.
 Apothecia straight and parallel..... 1a. *G. scripta recta*.

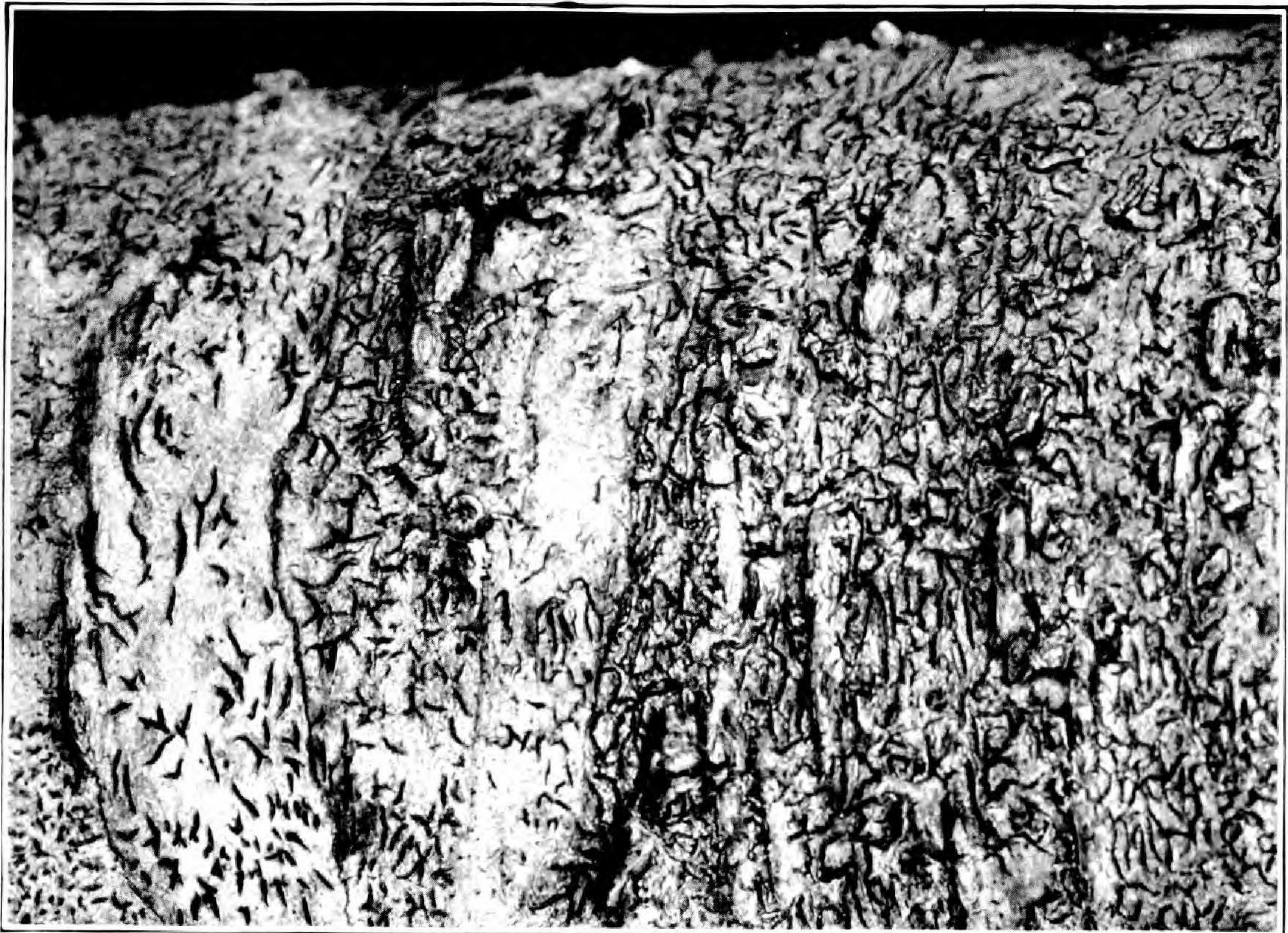
1. ***Graphis scripta*** (L.) Ach. Lich. Univ. 265. 1810.

PLATE 2, A.

Lichen scriptus L. Sp. Pl. 1140. 1753.

Thallus commonly showing plainly as a smooth, thin, whitish, ashy, or more rarely somewhat olivaceous crust, this either limited or widely spread over the substratum; apothecia usually much elongated, variously curved, sometimes branched, about 0.2 mm. in width and often 3 mm. or more in length, more or less superficial, the disk linear and appearing as a closed and often pruinose furrow, the proper exciple commonly veiled by the thin thalloid one; hypothecium dark brown; hymenium pale or pale brownish; paraphyses simple or rarely branched, frequently enlarged and darkened toward the apex; asci clavate or cylindrico-clavate; spores hyaline, oblong to linear with rounded ends, the exosporium wavy, usually 7 to 10-celled, 20 to 40 μ long and 7 to 9.5 μ wide.

Generally distributed over the State. On trees.



A. *GRAPHIS SCRIPTA* (L.) ACH.



B. *ARTHONIA RADIATA* (PERS.) ACH.

Also generally distributed throughout North America, and cosmopolitan in its foreign distribution.

EXPLANATION OF PLATE 2.—A, Plant of *Graphis scripta* on balsam fir, showing the elongated and variously curved apothecia and the whitish coloration due to the thallus. B, Plants of *Arthonia radiata* on balsam fir, showing the irregular apothecia and the whitish coloration due to the thallus. A enlarged $1\frac{3}{4}$ diameters; B enlarged $1\frac{1}{8}$ diameters.

1a. *Graphis scripta recta* Nyl. Not. Sällsk. Faun. Flor. Fenn. **5**: 252. 1861.

Apothecia straight and parallel or nearly so, in ours longer and often reaching 5 to 10 mm. in length; in ours also the epiphloeodal portion of the thallus, including the thalloid exciple, wanting, so that there appears to be no thallus.

It seems probable that this form might better have retained the status of a species. Throughout the northern portion of the State. On birches.

Distributed throughout the northern part of the United States and British America. Known also in Europe and Asia.

1b. *Graphis scripta serpentina* (Ach.) Nyl. Not. Sällsk. Faun. Flor. Fenn. **5**: 252. 1861.

Lichen serpentinus Ach. Lich. Suec. 26. 1798.

The epiphloeodal portion of the thallus unusually well developed, whitish and immersing the apothecia, and usually occurring in rather small areas upon the substratum.

Generally distributed over the State. On trees.

It is not possible to state the North American distribution of this subspecies, as it has been generally misunderstood. Our subspecies *limitata* of the preliminary reports undoubtedly belongs here, as the limiting dark line is almost uniformly wanting. Doubtless also the large number of specimens from British America called subspecies *limitata* are the present subspecies.

Known in all the grand divisions except Africa.

2. *Graphis dendritica* Ach. Lich. Univ. 271. *pl. 3. f. 16.* 1810.

Opegrapha dendritica Ach. Meth. Lich. 31. *pl. 1. f. 10.* 1803.

Thallus largely hypophloeodal, and the epiphloeodal film much as in the last species; apothecia more commonly immersed in the substratum and copiously radiate-branched, or in the less developed forms clustered, the cluster forming the radiate arrangement, and the individual apothecium less branched, the disk and proper exciple much as in the last species, but the thalloid veil rather less frequently present; internal characters also as in the last, but the spores shorter, containing fewer cells, and becoming colored and even dark-colored with age (4 to 8-celled, and 20 to 36 μ long and 5 to 8 μ wide).

Some of the material referred to *Graphis scripta limitata* in the preliminary reports may belong here, but a plant from Spicer County determined by Mr. W. W. Calkins appears much nearer this species externally. The spores of the latter, however, occasionally reach 10-celled conditions and they show only an occasional trace of color. On the other hand, a plant collected at Beaudette and less well marked externally shows the shorter, fewer-celled spores. Similar specimens have been collected in Illinois, Iowa, and Nebraska, but none of these northern plants are so well marked as those from the South, and it may well be doubted whether the species really occurs in any of these States.

Widely distributed in the Southern States and occurring all along our Atlantic coast. Also in Europe, Asia, and South America.

ARTHONIA Ach. Neu. Journ. Bot. Schrad. **13**: 3. *pl. 4.* 1806.

The thallus is rudimentary in structure and never shows any indication of cortical tissues. It is hypophloeodal in its early development and remains at least partly so in a large number of species. Under the best conditions it may become crustose and

in a few species it is sometimes areolate. The algal symbionts may be either *Cystococcus* or *Chroolepus*, and the relation between the fungal and the algal symbionts is unusually close, the algal cells or clusters being commonly entirely surrounded by fungal hyphæ or by haustoria. The thallus may be entirely dead and unnoticeable or quite prominent even in mature states.

The apothecia are sessile or more or less sunken in the substratum, or may even be covered by a thin layer of the substratum or the thallus. They are usually minute or small and most frequently irregular in form, though they may present a rounded condition and become quite biatoroid in external appearance. Stellate and linear forms are quite common. They are black or brownish black in ours, though other colors are frequent in other species. The hypothecium is usually brown, but may be darker or quite pale. The hymenium is pale, varying to brown. The paraphyses are usually branched and frequently scarcely differ from the fungal hyphæ in general appearance. The asci are commonly of the peculiar pyriform or subpyriform shape. The spores have 2, 4, or rarely more numerous cells, and are of the peculiar oblong-ovoid form frequently called slipper-shaped or soleæform. They are hyaline, pale, or rarely brown or brownish.

The genus is closely related to *Arthothelium*, as appears in the structure of the apothecia and the nature of the thallus. Perhaps it would be more consistent to separate the 2-celled species under the genus *Coniangium* Fr.^a *Arthonia* properly stands next to *Arthothelium*, but is scarcely higher than *Opegrapha* and *Graphis*.

The genus is southern in range, and only 6 or 7 forms have been found in Minnesota.

The plants are found on trees, usually species with smooth bark.

Type species *Arthonia versicolor* Ach. loc. cit. The plant is uncertain, but the plate shows a plant externally like *Arthonia radiata* (Pers.) Th. Fr.

KEY TO THE SPECIES.

- Thallus epiphloeodal..... 4. *A. lecideella*.
 Thallus mainly or wholly hypophloeodal.
 Spores 2-celled.
 Apothecia rounded..... 1. *A. patellulata*.
 Apothecia varying from rounded to some other form.
 Apothecia rounded to round-oblong..... 2. *A. convexella*.
 Apothecia rounded to difform..... 3. *A. dispersa*.
 Spores 4-celled (rarely more).
 Apothecia tending toward rounded forms..... 6a. *A. radiata swartziana*.
 Apothecia not rounded.
 Apothecia oblong, difform, or sublinear..... 5. *A. punctiformis*.
 Apothecia difform, stellate, or ramose..... 6. *A. radiata*.

1. *Arthonia patellulata* Nyl. Nya Bot. Notis. **1853**: 95. 1853.

Thallus occurring in patches from 6 to 40 mm. across, white or varying toward sea-green or olivaceous, mostly hypophloeodal or quite conspicuous and thick above the substratum, sometimes dying away, the thicker conditions usually more or less roughened; apothecia black, rounded, adnate or immersed, plane, minute or small, 0.3 to 0.6 mm. in diameter; hypothecium brownish to brownish black; hymenium pale or more commonly brownish; paraphyses somewhat gelatinized, but more or less branched and scarcely differing from the fungal hyphæ; asci broadly clavate to subpyriform; spores 2-celled, soleæform, 10 to 14 μ long and 3 to 5 μ wide.

The forms with thick dark thalli may belong to *Arthonia ruderalis* Nyl. ^b

^a Fries, Syst. Orb. Veg. 27. 1825.

^b Mem. Soc. Sci. Nat. Cherb. **4**: 100. 1856.

Collected in several widely separate portions of the State and no doubt generally distributed. The plant resembles certain Lecideas externally and is easily overlooked. On trees, especially on poplars.

The species is reported from widely separate portions of North America, but neither from the extreme north or south. Also known in Europe.

2. *Arthonia convexella* Nyl. Act. Soc. Linn. Bord. **2**: 415. 1856.

Thallus white, ashy, or greenish, partly epiphloeodal but thin and smooth and frequently dying away, the patches in material examined scarcely exceeding 20 or 30 mm. across; apothecia black, rounded or rounded-oblong, convex and rugulose, minute, 0.2 to 0.4 mm. in diameter; hypothecium heavy and blackish brown; hymenium brown or reddish brown; paraphyses usually branched and resembling the hyphæ, the apex brownish; asci broadly clavate or subpyriform; spores 2-celled, hyaline to brown, soleæform, 11 to 14 μ long and 4 to 6 μ wide.

Differs from ours of the last in the brown spores and the smaller, more convex apothecia.

Once collected in the State at Beaudette, along the international boundary, on balsam.

The only other station for the plant found reported is in France.

3. *Arthonia dispersa* (Lam. & DC.) Duf. Journ. Phys. Chem. Nat. Hist. **87**: 203. 1818.

Opegrapha dispersa Lam. & DC. Fl. Fr. ed. 3. **2**: 308. 1805.

Thallus white or whitish, mainly hypophloeodal, thin, smooth, occurring in patches from 6 to 70 mm. in longest dimension, or these running together and covering larger areas; apothecia punctiform, rounded, oblong, difform, or even branched, commonly more or less immersed in the thallus or the substratum, minute, the dimensions 0.1 to 0.4 mm.; hypothecium thin, pale or pale brownish; hymenium pale or very pale brownish; paraphyses not distinctly seen, probably merely a mass of more or less gelatinized hyphæ; asci pyriform; spores 2-celled, soleæform, 11 to 16 μ long and 4 to 5 μ wide.

The most common and most widely distributed of the genus in Minnesota. On trees, especially common on *Acer spicatum* in the northern portion of the State.

Apparently generally distributed throughout the United States, and extending at least as far north as Newfoundland. Known also in Europe.

4. *Arthonia lecideella* Nyl. Mém. Soc. Sci. Nat. Cherb. **5**: Suppl. 337. 1857.

Thallus greenish to sea-green or lighter, rather thick, continuous or rarely subareolate, uneven and epiphloeodal, occurring in irregular patches 5 to 25 mm. in the longest diameter and sometimes running together and covering larger areas of the substratum; apothecia dark brown or black or frequently grayish-pruinose, quite numerous, plane or convex, rounded, small, 0.2 to 0.4 mm. in diameter, immersed or adnate; hypothecium brown or dark brown; hymenium light brown or at least brownish; paraphyses short-jointed and freely branched, the apices of the branches sometimes enlarged and darker; asci clavate to subpyriform; spores soleæform, 4-celled, 16 to 23 μ long and 5 to 6.5 μ wide.

Generally distributed over the State. On trees and old wood.

A strictly North American lichen, common in the Mississippi Valley, ranging eastward to the Atlantic and northward into British America.

5. *Arthonia punctiformis* Ach. Lich. Univ. 141. 1810.

Thallus mainly hypophloeodal and finally dying away, when present giving a whitish cast to the substratum, occurring in irregular patches frequently reaching 75 mm. or more in the longest dimension; apothecia oblong, sublinear or more commonly difform or even rounded, black, plane or slightly convex, adnate or immersed, minute, 0.1 to

0.2 mm. in diameter or in the short dimension of the elongated forms; hypothecium pale or pale brownish; hymenium pale; paraphyses scarcely differing from the hyphæ of the thallus; asci pyriform or subpyriform; spores 4-celled (or rarely 5 or 6-celled), soleæform, 15 to 22 μ long, 4.5 to 7 μ wide.

Generally distributed over the State. On trees and confined to smooth bark. A number of subspecies have been recognized based on the number of cells in the spores and the form of the apothecia.

Distributed throughout North America, except possibly the extreme north. Also well known in Europe and Asia.

6. *Arthonia radiata* (Pers.) Ach. Lich. Univ. 144. 1810.

PLATE 2, B.

Opegrapha radiata Pers. Ann. Bot. Usteri 7: 29. 1794.

Thallus sea-green varying toward whitish or brownish, partly or wholly hypophlœodal and rarely entirely dying away, occurring in more or less irregular patches, reaching 5 to 30 mm. in diameter and rarely bordered wholly or in part by a dark line, the thalli frequently running together and covering much larger areas of the substratum; apothecia stellate, difform, or ramose, adnate or more commonly immersed, rarely erumpent, black, plane or slightly convex, rather large for the genus, 0.4 to 1.5 mm. in the longest dimension; hypothecium pale brown; hymenium pale or brownish; paraphyses simple or branched, with enlarged brownish apex; asci broadly clavate or subpyriform; spores 4-celled, soleæform, 12 to 20 μ long and 4 to 6 μ wide.

Generally distributed over the State. On trees, confined to smooth bark and usually to rather young trees.

The plant is widely distributed in North America and is general in its foreign distribution also. Several subspecies are recognized, few of which seem to have any value.

EXPLANATION OF PLATE 2.—See page 55.

6a. *Arthonia radiata swartziana* (Ach.) Willey, Syn. Arth. 44. 1890.

Arthonia swartziana Ach. Neu. Journ. Bot. Schrad. 1³: 13. pl. 4. f. 1. 1806.

Apothecia larger and more commonly rounded; spores also rather larger.

What seems to be this subspecies was collected in the northern portion of the State at Rainy Lake City and at Tower. Habitat same as that of the species.

Widely distributed in the United States and British America. Also known in Europe and Africa.

ARTHOTHELIUM Mass. Ric. Lich. 54. f. 101. 1852.

Like *Arthonia*, the genus has a rudimentary thallus without cortical tissues. But the thallus is on the whole better developed than in the foregoing genus, commonly becomes largely or wholly epiphlœodal, and rarely, if ever, entirely disappears. It is frequently quite thick and uneven and rarely even areolate. The algal symbiont is *Chroolepus*, at least so far as has been ascertained.

The apothecia are adnate, or more or less sunken in the thallus or substratum. They are usually small and rounded or irregular in outline. The color is black or rarely brownish black. The hypothecium is usually brown, though it may vary to dark brown or pale. The hymenium is pale to brown. The paraphyses are usually much branched, but are quite commonly simple in some species. The asci are usually of the peculiar pyriform or subpyriform shape. The spores are many-celled and muriform, large in size, and still quite constantly 8 in each ascus, and they may be hyaline, pale, or brown in color.

The genus is closely related to *Arthonia* as to structure of thallus and yet more as regards the apothecia. Though the spores are usually quite different and apparently

nearer Dermatocarpon and related genera, there are submuriform conditions which seem to bridge over the gap between Arthothelium and Arthonia.

Though the genus comprises about 50 species, only a half dozen are known in North America, and but a single one exists in Minnesota.

Our plant is found only on trees.

Type species *Arthothelium spectabile* Mass. loc. cit.

Arthothelium spectabile Mass. Ric. Lich. 54. f. 101. 1852.

Thallus mainly epiphloeodal and quite thick, whitish or grayish, sometimes in small patches, but more commonly covering large areas of the substratum, even 200 mm. or more in diameter, frequently bordered or dissected more or less by dark lines, smooth or roughened or even subareolate; apothecia difform, angulate, oblong or variously irregular, often immersed in the thallus, black, plane or convex; hypothecium brown or dark brown; hymenium brownish or brown; paraphyses much branched, hyaline or slightly brownish, the apices sometimes enlarged and more deeply colored; asci pyriform; spores ellipsoid, muriform, hyaline, or brownish, 8 in the asci, 28 to 38 μ long and 10 to 16 μ wide.

The plant has not been noted in the State, but is well known in northern Iowa and surely occurs in southern Minnesota. The species resembles *Arthonia radiata* externally and is easily overlooked. It is most common on hickory.

Known more or less from the Atlantic to the Pacific and from Florida as far north at least as Newfoundland. Also found in South America, Europe, and Asia.

Family LECANACTIDACEAE.

The family is a small one and represented in our flora by only two genera, each represented by a single species, and these both rare or seldom noted. One of the two genera, Lecanactis, is northern in distribution and the other is southern.

The members of the family all have a crustose thallus, frequently hypophloeodal and scarcely better developed than the thalli of the Graphidaceae. The algal symbiont is likewise *Chroolepus*, and the members of the family are all transitional forms, closely related to the Graphidaceae as to thallus structure and perhaps more closely to the Lecideaceae as to apothecial characters.

Both of the species assigned to the present family are sure to prove troublesome if found. The *Melaspilea* is likely not to be considered a lichen, as the thallus is frequently wanting. If taken for a lichen, it is likely to pass for a Lecidea or an *Opegrapha*. But the peculiar spores, consisting of two spheroidal cells should fix the plant. The *Lecanactis* is as likely to pass for a *Bilimbia*, but it may be known by its stronger, black, and persistent proper exciple.

MELASPILEA Nyl. Act. Soc. Linn. Bord. 21: 416. 1856.

The thallus is crustose, mainly hypophloeodal, so giving a smooth and widely extended crust, ashy in color, devoid of any differentiation into layers, the epiphloeodal portions at least quite commonly disappearing, in which case the thallus is said to be absent. The algal symbiont is *Chroolepus*-like.

The apothecia are rounded or oblong, in the former condition appearing lecideoid and in the latter more like *Arthonia* or *Opegrapha*. They are, however, superficial. The disk is black and flat or convex. The proper exciple is also black. The spores are 2-celled, commonly hyaline, and oblong, obtusely ellipsoid, or slipper-shaped.

Like *Lecanactis*, the present genus seems to be a transitional one with very similar relationships, the species having formerly been assigned to *Lecidea*, *Opegrapha*, *Arthonia*, etc.

A single species has been found in Minnesota.

Type species *Melaspilea arthonioides* (Fée) Nyl. loc. cit.

Melaspilea arthonioides (Fée) Nyl. Act. Soc. Linn. Bord. 21: 416. 1856.

Lecidea arthonioides Fée, Essai Crypt. 107. 1824.

Thallus as above; apothecia circular in outline or rarely somewhat oblong, scarcely reaching middle size, 0.4 to 1 mm. in diameter, adnate or at first more or less immersed, the disk black, plane or convex, the exciple black and prominent or rarely disappearing; hypothecium dark brown; hymenium pale below and brownish above; paraphyses simple or rarely branched, commonly enlarged and colored toward the apex; asci clavate; spores hyaline in ours at least, constricted at the septum so that each of the two cells frequently is spheroidal in form, 12 to 17 μ long and 6 to 8.5 μ wide.

Generally distributed in the State, but easily overlooked. On trees.

Elsewhere in North America in New England, Iowa, and Nebraska, the specimen from the latter State, determined by me for J. M. Bates, collected in 1898. Known also in Europe, Africa, and South America.

LECANACTIS Eschw. Syst. Lich. 14. 25. f. 7. 1824.

FIGURE 8.

The thallus is crustose, consisting of a continuous or scattered crust, sometimes chinky or verrucose, but scarcely reaching plainly areolate conditions, sometimes

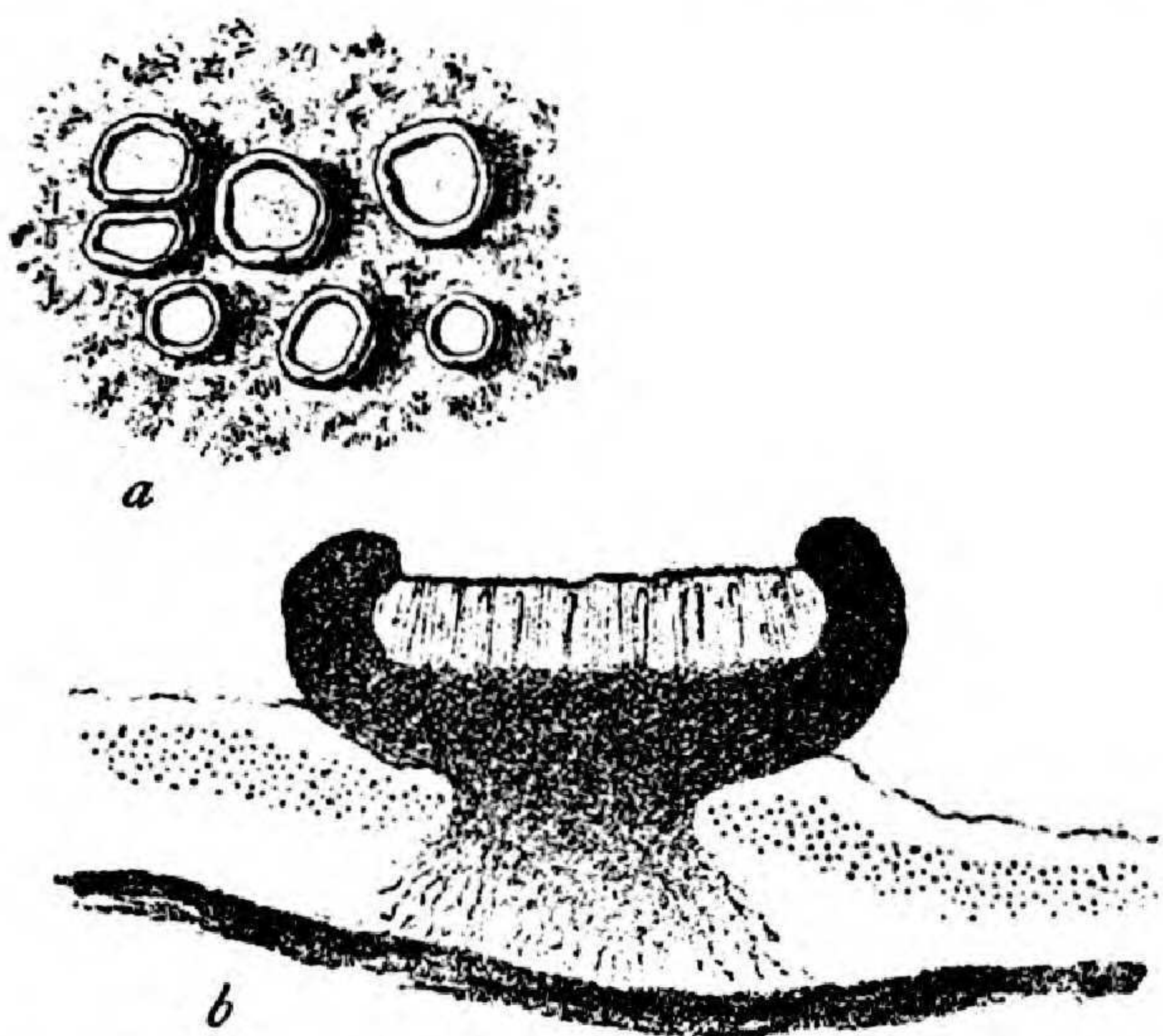


FIG. 8.—*Lecanactis abietina*. a, Plant; b, section of the thallus, showing the heavy, dark proper exciple and the hymenium within. Enlarged 40 diameters. From Reinke.

scurfy or mealy, without cellular cortex or medullary or algal layers. The algal symbiont is plainly *Chroolepus*, showing the cells linked together in the usual form, but the algæ are peculiar in that they often show a reddish yellow color. The above characters of the thallus, especially the nature of the algal symbiont, are quite like those of the present suborder, but the apothecial characters are, in some of the species, more like those of the *Lecideaceae*.

The apothecia are commonly rounded, but sometimes oblong, and have a black proper exciple. The spores are 4 to several-celled, finger-shaped or fusiform, hyaline. The lecideoid nature of the apothecia has led some lichenists to place the

plants, or part of them, with the *Lecideaceae*, and surely there is ground for this view.

The present genus is, then, a transitional form, showing close relationship with two suborders of lichens, the rounded apothecia of some species being much like those of *Lecidea*, but the spores being more like those of the present suborder. However, the species having oblong apothecia are in this respect quite as near certain forms of *Opegrapha*.

A single species is known in Minnesota.

Type species *Lecanactis lobata* Eschw. loc. cit.

1. **Lecanactis premnea** (Ach.) Tuck. Proc. Amer. Acad. 12: 284. 1866.

Lecidea premnea Ach. Lich. Univ. 173. 1810.

Thallus a thin, continuous, smoothish or variously roughened, granulate or chinky crust, widely and irregularly spread over the substratum, greenish, sea-green, or ashy in color, sometimes surrounded by a blackening hypothallus; apothecia middle-sized, 0.75 to 1.5 mm. in diameter, rounded or becoming flexuous, sessile, the disk usually flat, black and commonly greenish-pruinose, the prominent exciple black and persistent; hypothecium dark brown; hymenium pale or brownish; paraphyses

simple or rarely branched, frequently enlarged and darkened toward the apex; asci cylindrico-clavate or cylindrical; spores fusiform-oblong and frequently curved, 4-celled, hyaline, 13 to 22 μ long and 3 to 5 μ wide.

Once collected along the northern boundary at Emo, Ontario. On cedars.

Elsewhere in North America in California, South Carolina, Alabama, and Ohio. Known also in Europe and Asia.

This was determined by T. Hedlund as *Lecanactis chloroconia* Tuck., and the plant was so recorded in the seventh preliminary report. Tuckerman reduced his plant to a subspecies of the above species, but the spore measurements in our plant seem to connect it with the type rather than the subspecies.

Family GYALECTACEAE.

Like the last family, the present one is represented in our flora by a few very rare species. The three genera to which these belong show some external resemblance in the commonly urceolate disk, the proper exciple, and the usually evanescent thalloid one. Indeed, *Gyalecta* and *Secoliga* are certainly closely related genera, as shown both in the thallus and in the apothecial characters. However, the stronger, dark proper exciple of *Conotrema* would seem to make its position in the family doubtful. But though the exciple sometimes nearly closes the disk, we can not think that the genus should be placed with the *Pyrenulaceae*. Yet it is readily admitted that the family, *Gyalectaceae*, is not a very natural one and that the genera might perhaps as well be parceled out to other families as is done by some authors.

The thallus is crustose in all of our plants, but minutely foliose forms occur elsewhere. It is usually thin and granular and sometimes evanescent, so that the plants appear much like closely related fungal *Discomycetes*. This is especially true in the first two genera. The algal symbiont is at least commonly *Cystococcus*.

The first two genera are also closely related as to spore characters, but here again *Conotrema* seems quite distinct.

The genus *Urceolaria*, which we have placed with the *Physciaceae*, is frequently regarded as a member of the present family.

While the family should, on the whole, doubtless stand next below the *Lecideaceae*, the poorly developed and usually evanescent thalloid veil or exciple seems to indicate a relationship with the *Lecanoraceae*. However, we must not lose sight of the fact that some of the *Lecideaceae* also show some hint of a thalloid exciple.

GYALECTA Ach. Lich. Univ. 30, 151. *pl. 1. f. 7-9.* 1810.

The thallus, in the American forms at least, is crustose and without a distinct cortex. The color is commonly sea green, varying toward greenish, ashy, or brownish. The structure is usually thin or very thin and variously smooth, chinky, granulate, leprose, or powdery, and frequently disappears. Some of the higher forms are said to possess upper and lower cortices, but we have not examined species having such layers. The algal symbionts are forms of *Cystococcus*, or according to some observers *Chroolepus*.

The apothecia are commonly sessile and minute, though in a few species they may reach middle size. They are commonly more or less urceolate, and are uniformly surrounded by a somewhat colored proper exciple. Rarely a variously imperfect and more or less evanescent thalloid exciple surrounds the proper one. The hypothecium and the hymenium are commonly pale, and the paraphyses are usually simple, though compound ones may be found in some of the species. The asci vary from clavate to cylindrico-clavate. The spores are hyaline and 2-celled, though 4-celled species have commonly been admitted to the genus, and Tuckerman admitted even 10-celled forms, which we place under *Secoliga*.

The relations of the genus are very uncertain. The presence of the thalloid exciple in some species looks toward *Lecanora*; but such a structure also occurs in certain

Lecideas, and indeed the present genus seems much nearer to the closely related *Biatorina*. Possibly we should do better to follow some authors and place our species with the *Biatorinas*.

A single species has been met in the State. On wood and moss.

Type species *Gyalecta epulotica* Ach. loc. cit.

This is a *Lecanora*, and priority of paging would require that *Gyalecta* replace *Lecanora*. But again, *Parmelia* Ach. would take precedence over both *Gyalecta* and *Lecanora*. Again, it appears from work already done on typification of lichen genera that both *Lecanora* and *Parmelia* will have to give way to earlier names, if we follow rules of priority. This is but one example of the involved questions that arise regarding the validity of lichen genera.

1. *Gyalecta lutea* (Dicks.) Tuck. Gen. Lich. 131. 1872.

FIGURE 9.

Lichen luteus Dicks. Pl. Crypt. Brit. 1: 11. pl. 2. f. 6. 1785.

Thallus a thin, smoothish or minutely roughened crust, variously spread over the substratum as a continuous or more or less broken layer, greenish and varying toward ashy (the latter perhaps the more typical color when free algæ are not scattered over the surface), sometimes becoming very inconspicuous or disappearing; apothecia minute (in ours at least), 0.2 to 0.4 mm. in diameter, sessile, urceolate or becoming flattish, the disk pale yellowish or flesh-colored, the proper exciple commonly lighter

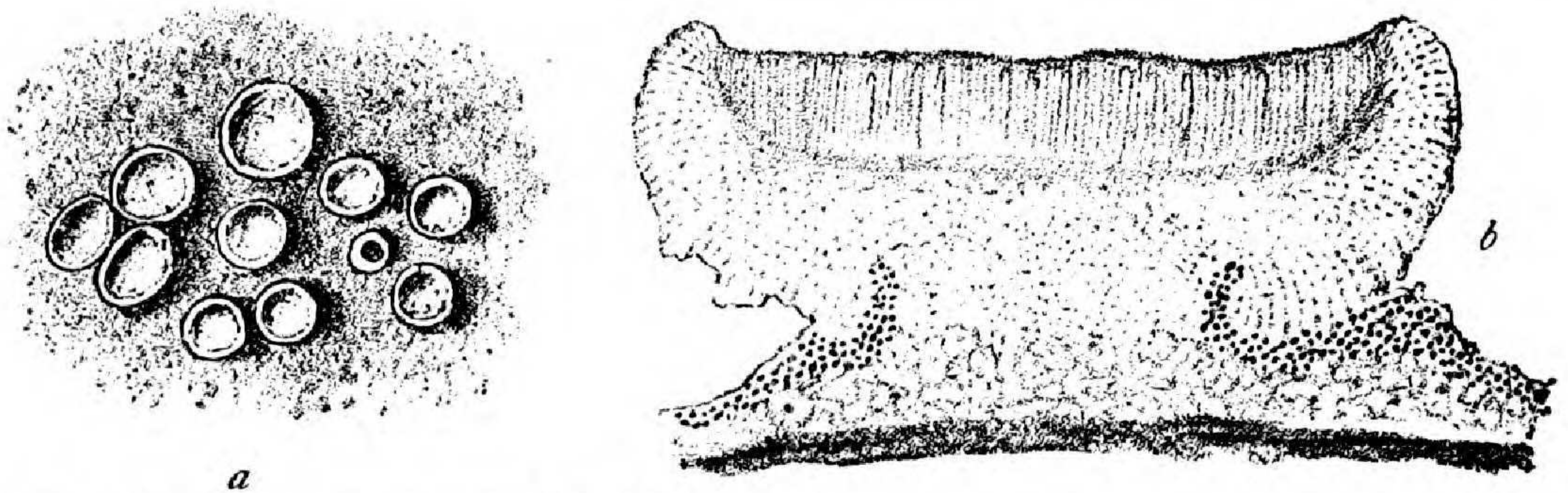


FIG. 9.—*Gyalecta lutea*. *a*, Several apothecia; *b*, section of an apothecium, showing the exciple, the hypotheceum, and the hymenium. *a*, Enlarged 6 diameters; *b*, 90 diameters. From Reinke.

colored and sometimes obscurely striate, a very thin thalloid exciple also rarely to be distinguished in sections; hypotheceum and hymenium pale, or the latter yellowish above; paraphyses commonly simple, sometimes slightly thickened toward the apex, asci cylindrico-clavate; spores fusiform-ellipsoid, 6 to 11 μ long and 3 to 4 μ wide.

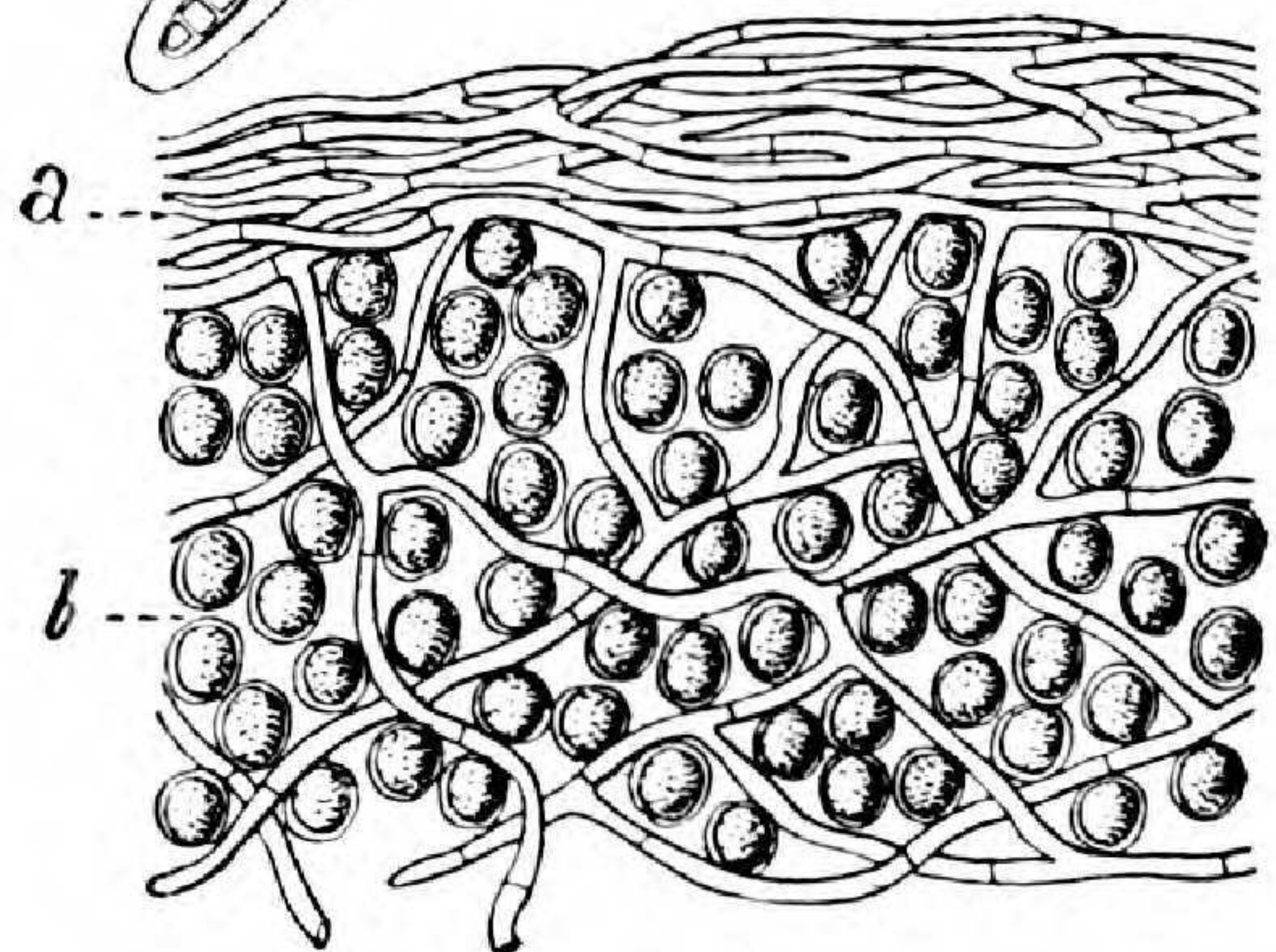
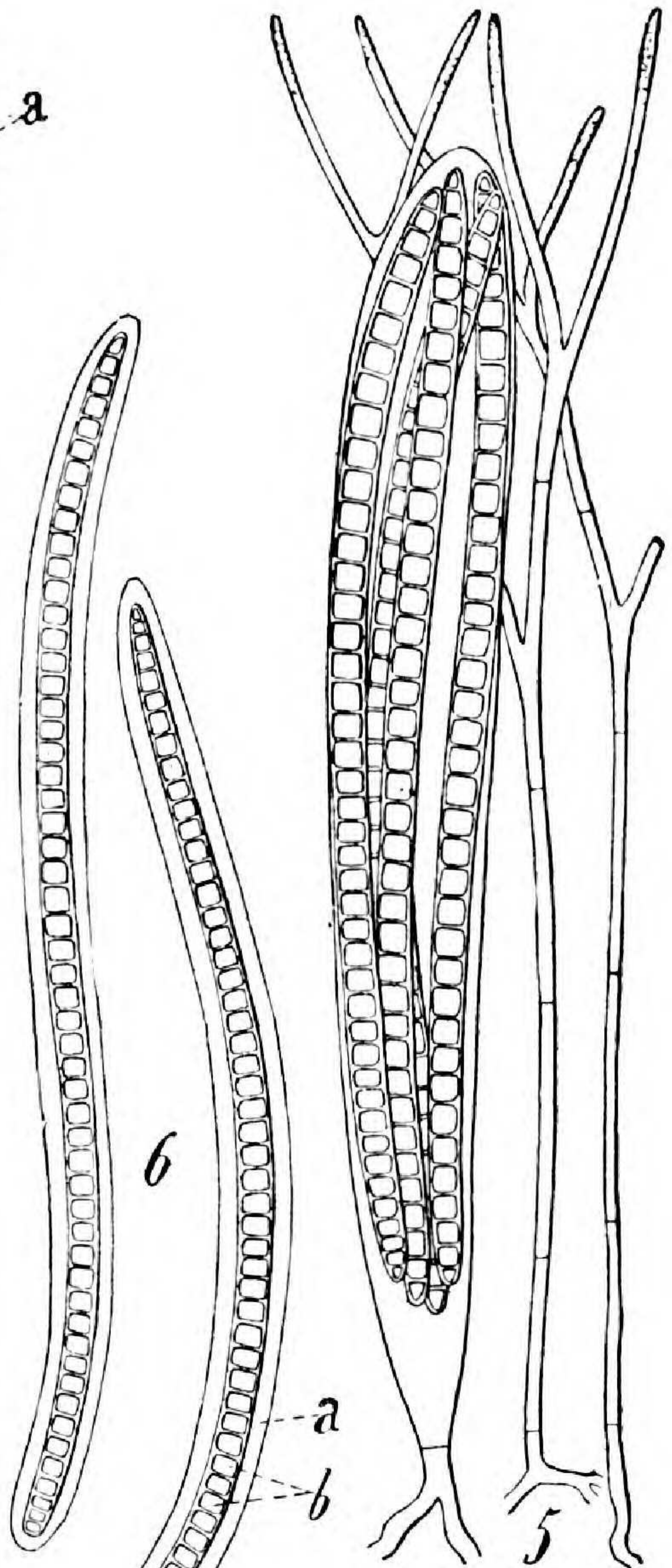
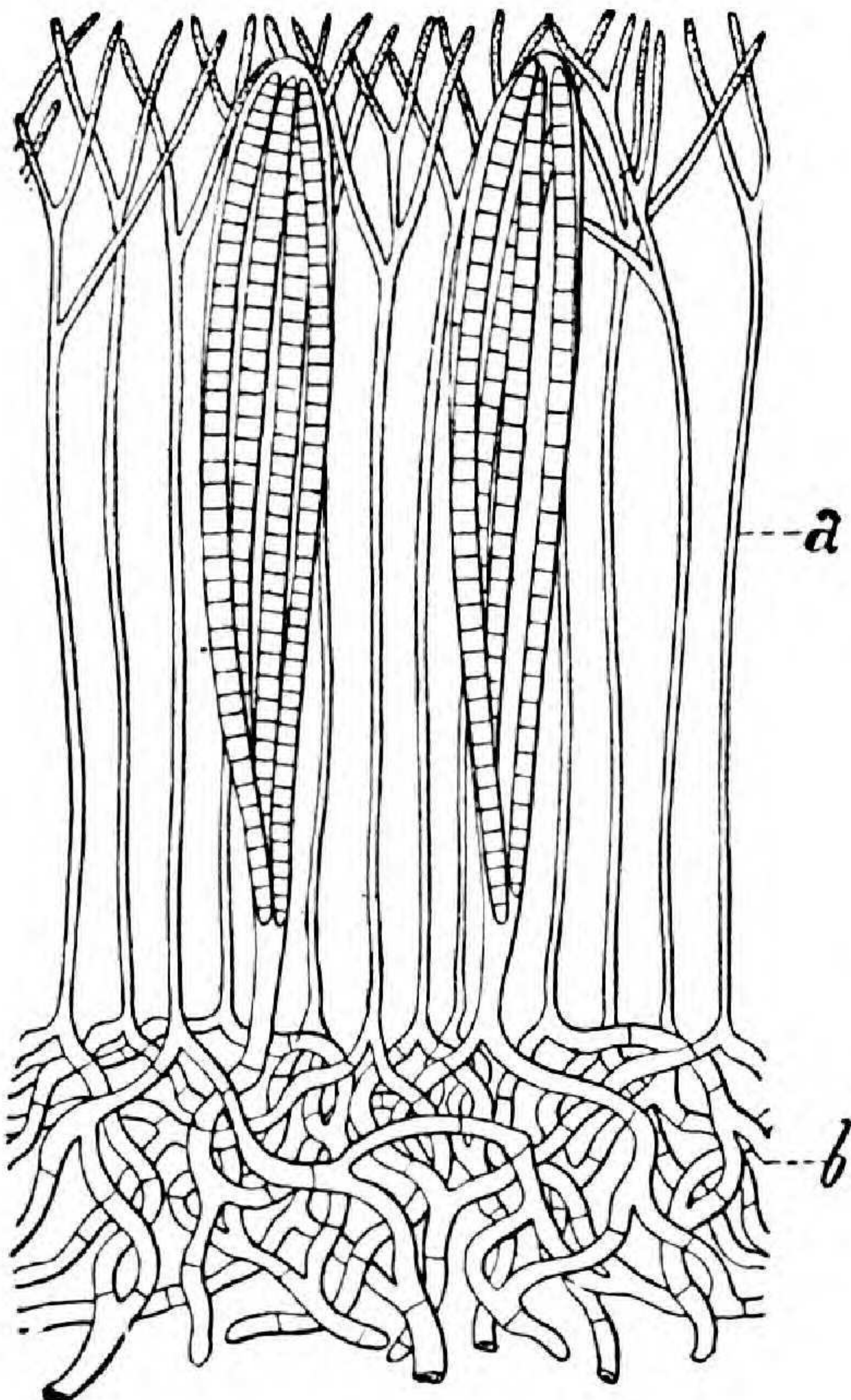
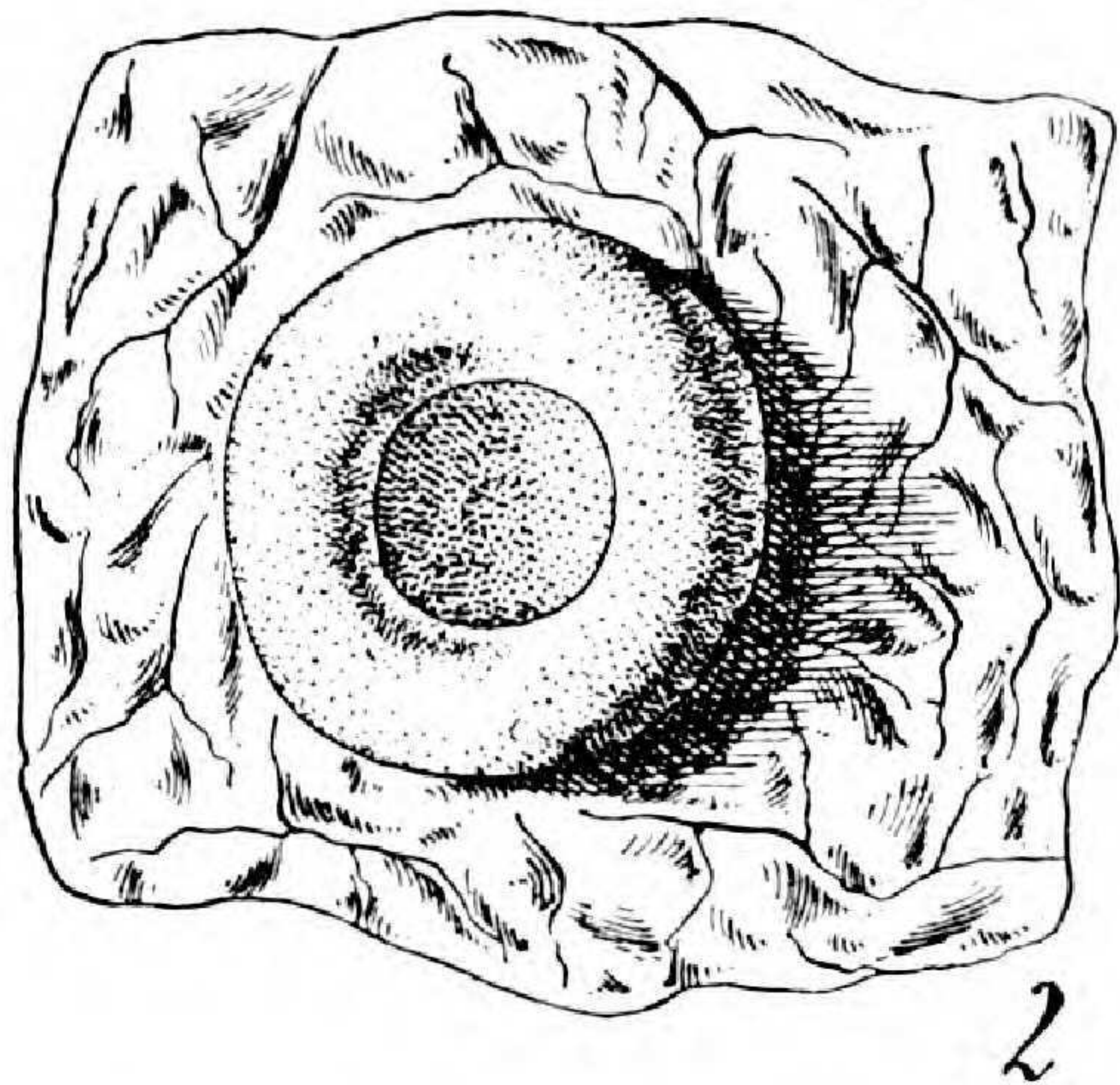
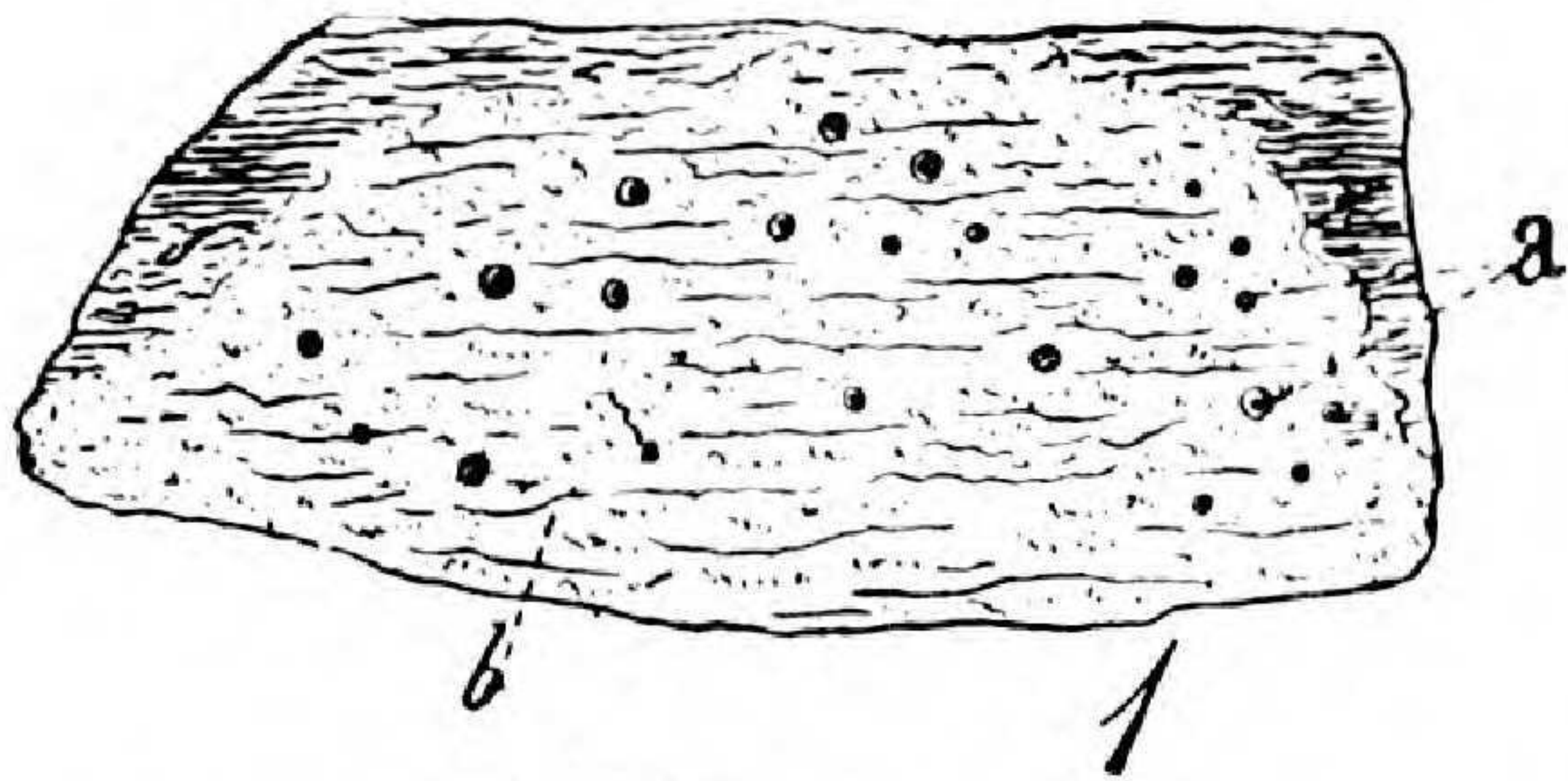
Collected on the islands belonging to the United States in Lake of the Woods, and at Emo on the northern boundary. On wood and mosses.

Elsewhere in North America in New England, New York, Florida, Alabama, Illinois, Iowa, Nebraska, Ontario, and Manitoba. Known also in all of the grand divisions.

SECOLIGA Norm. Nyt. Mag. Naturv. 7: 230. pl. 1. f. 9 *b*, 10 *c*, *d*; pl. 2. f. 24 *a*. 1853.

The thallus is essentially like that of the *Gyalectas*, crustose and without a distinct cortex. In color and thickness, as well as in general appearance, the resemblance is quite as great.

The apothecia are also commonly minute and sessile. They are usually more or less concave or even urceolate, and the surrounding proper exciple is more or less colored. The thalloid exciple is scarcely ever seen, if present at all, and was not observed in our species. The hypotheceum and the hymenium are pale, or the latter slightly colored above. The paraphyses were simple in the material examined, and the asci were cylindrico-clavate. The spores are hyaline and 4-celled, or in some of the species they may pass from 4 to 10-celled or muriform conditions.



3

4

CONOTREMA URCEOLATUM (ACH.) TUCK.

The relationship of the present genus is quite as obscure as that of *Gyalecta*, but after *Gyalecta* the genus is doubtless most closely related to *Bilimbia*.

Two species have been met in the State. On trees.

Type species *Secoliga cupularis* (Ehrh.) Norm. loc. cit.

KEY TO THE SPECIES.

On trees; exciple entire.....1. *S. fagicola*.
On rocks; exciple radiately striate.....2. *S. cupularis*.

1. ***Secoliga fagicola*** Hepp.; Koerb. Par. Lich. 112. 1865.

Thallus very thin and somewhat chinky or scaly-roughened, pale greenish or becoming brownish, irregularly spread over the substratum as a continuous or more or less broken layer, or sometimes disappearing; apothecia very minute, 0.15 to 0.3 mm. in diameter, sessile, the disk commonly concave and flesh-colored, or becoming rusty-red and blackening, the proper exciple entire and of the same color as the disk (no evidence of a thalloid exciple seen); hypothecium and hymenium pale, or the latter sometimes darker above; paraphyses slender and commonly simple; asci clavate; spores fusiform or pointed-fusiform, 4 to 10-celled, 15 to 40 μ long and 3 to 6 μ wide, 8 to 20 in each ascus.

Collected along the shores of Snowbank Lake. On trees.

Elsewhere in North America in Massachusetts. Known also in Europe.

Gyalecta fagicola of the preliminary reports.

2. ***Secoliga cupularis*** (Ehrh.) Norm. Nyt. Mag. Naturv. 7: 230. pl. 1. f. 10 c. 1853.

Lichen cupularis Ehrh. Beitr. Naturk. 4: 45. 1789.

Thallus thin, somewhat scurfy or smoother and chinky, greenish ash-colored or becoming darker, irregularly and widely spread over the substratum as a continuous or more or less broken layer; apothecia small or minute, 0.25 to 0.5 mm. in diameter, adnate or rarely sessile, urceolate or more open and shallower, the disk brick-red or paler, the proper exciple whitish and radiately striate or becoming smooth; hymenium and hypothecium pale; paraphyses distinct, simple and pale throughout; asci cylindrical or cylindrico-clavate; spores ellipsoid, muriformly several-celled, 13 to 17 μ long and 6 to 9 μ wide, 8 in each ascus.

On shaded rocks at Pork Bay. Not previously reported from Minnesota.

Elsewhere in North America from several States bordering on the Atlantic. Known also in Europe and New Zealand.

CONOTREMA Tuck. Syn. Lich. N. E. 86. 1848.

PLATE 3.

The crustose thallus is quite rudimentary in structure and without distinct layers. There is, however, a greater or less development of superficial hyphæ running for the most part in a horizontal direction and forming a protective and poorly pseudocortical layer. The structure is mostly epiphloeodal, strictly crustose, thin, smooth or somewhat roughened. Cystococcus is the algal symbiont. Hyphal rhizoids form the attaching organs.

The apothecia are small and more or less immersed in the thallus and partly hypophloeodal. However, the thallus partly disappears with age and the larger apothecia appear to be sessile. There is a dark proper exciple and in the early development, at least, this is surrounded by a thin thalloid one. The hypothecium and the hymenium are pale. The asci are cylindrical. The spores are also cylindrical, many-celled, and hyaline. The paraphyses are commonly branched toward the apex.

The genus is represented by a single species and its relationships are by no means certain. The so-called apothecium is perhaps as nearly a perithecium. It is deeply

urceolate, and the disk tends toward closed conditions like those encountered in the perithecia of *Verrucaria* and allied genera. The presence of *Cystococcus* instead of *Chroolepus* looks toward the present family, to which the present genus is doubtless more closely related. The spores are, however, quite different.

The single species has been met once in the State. On trees.

Type species *Conotrema urceolatum* (Ach.) Tuck. loc. cit.

EXPLANATION OF PLATE 3.—Fig. 1, *a*, an apothecium; *b*, thallus, natural size. Fig. 2, an apothecium and a portion of the thallus. Fig. 3, section of an apothecium; *a*, the hymenium; *b*, the hypothecium. Fig. 4, a section of the thallus; *a*, the pseudocortex of entangled hyphæ; *b*, the layer of algal cells and fungal hyphæ below. Fig. 5, paraphyses and an ascus. Fig. 6, free compound spores; *a*, the exosporium; *b*, the cell lumina. Fig. 1, natural size; fig. 2, enlarged about 20 diameters; figs. 3, 4, enlarged about 400 diameters; figs. 5, 6, enlarged 650 diameters. From Schneider.

Conotrema urceolatum (Ach.) Tuck. Syn. Lich. N. E. 86. 1848.

PLATE 3.

Lecidea urceolata Ach. Syn. Meth. Lich. 27. 1814.

Thallus crustose, thin, and smooth, or becoming somewhat chinky, scurfy, or more or less distinctly areolate, ashy-whitish, sometimes partly disappearing, a layer of mostly horizontally interwoven hyphæ forming somewhat of a protective pseudocortex, somewhat orbicular and 15 to 65 mm. across, or irregular and more widely spread over the substratum; apothecia small or subminute, 0.4 to 0.75 mm. in diameter, partly hypophlœodal, but extending above the thin thallus and usually appearing externally to be adnate or sessile, deeply urceolate and commonly more or less white-pruinose within, the exciple proper, blackish, at first surrounded by a thin thalloid one; hypothecium and hymenium pale, or the latter sometimes darker above; paraphyses more or less branched toward the apex, there also slightly thickened and darker; asci cylindrical; spores cylindrical, 100 to 160 μ long and 3 to 4.5 μ wide, 30 to 40-celled.

Collected at Hibbing in the northern part of the State, by Anna M. Kimball. On trees.

Throughout the eastern half of North America, in mountains toward the south. Known also in South America and Europe.

Family LECIDEACEAE.

Unlike the last two families, the present is one of the largest in our Minnesota lichen flora, including many species and some of our best-known lichens. Notwithstanding the large number of genera included, there is considerable similarity in apothecial structure throughout. Indeed, taking only this apothecial structure into account, the genera of the family would seem to be closely related, exhibiting various conditions in the evolution of a strong and persistent proper exciple. Doubtless some members of the Patellariaceae are the fungal ancestors of all the members of the present lichen family, but when we consider the great range of difference in the spore characters in the Lecideaceae, including, indeed, the extremes in spore evolution, viz, the simple hyaline spore and the brown muriform spore, we can only suppose that the various genera must have arisen from quite different fungal ancestors.

The thallus is crustose in the family as limited in this volume, and varies from inconspicuous and evanescent leprose or granular conditions to verrucose, areolate, or even subsquamulose states. The apothecia are commonly rounded, and are so much alike in the different genera that one often can not be certain even of the genus in the field. However, the darker apothecia, as a rule, belong to the genera having the stronger exciples. Some suggestion of a thalloid exciple may be made out, outside the proper one, in a few species. The algal symbiont is *Cystococcus*, except perhaps in some *Biatorinas*.

The family is closely related to the Baeomycetaceae, differing mainly in the absence of a stipe, and also certain transitional forms with some showing of thalloid exciple seem to look toward the Lecanoraceae. Finally, the genera having brown

spores are doubtless somewhat closely related with the Physciaceae, especially *Buellia* with *Rinodina* and *Rhizocarpon* with *Urceolaria*.

BIATORELLA De Not. Giorn. Bot. Ital. 2¹: 192. 1846.

The thallus is crustose and commonly granulose, sometimes verrucose or subareolate, and is on the whole much less developed than in *Lecidea*. Indeed, it is quite commonly evanescent or so rudimentary as to appear only with the most careful examination with lens or even in section with microscope. Of course there is no cortex, nor can algal and medullary layers be distinguished. The thin and rudimentary structure lies mainly above the substratum to which it is attached by hyphal rhizoids. The algal cells seem to be *Cystococcus*.

The apothecia are commonly minute or at least small, though they may reach middle size in one of our species. The exciple is of the lecideoid type, composed of closely interwoven hyphæ, and is frequently evanescent. It is usually light in color, but may be darker and firm as in the higher members of *Lecidea*. The disk may be flat or convex and in the latter condition frequently overgrows the exciple. The exciple, however, may be persistent and raised somewhat above the border of the disk. Both hypothecium and hymenium vary from pale to brown. The spores are minute and numerous in the asci, though in one species not represented in our flora there are only 12 to 18 spores in each ascus. They are simple and are globular to oblong or ellipsoid in form.

The present genus is closely related to *Lecidea*, though possibly nearer *Bacidia* or *Bilimbia*, as the minute and numerous spores may have arisen from a breaking up of the long compound spores of members of these genera to form the minute and more numerous ones of the present genus. Tuckerman has included in *Lecidea* and *Heterothecium* forms having minute and numerous spores. We do not encounter these among our Minnesota species, but it is evident that they should all be brought together into one genus, or possibly two closely-related genera. We have also transferred *Lecanora privigna* to the present genus under the older synonym *Biatorella simplex*.

The genus has four species and subspecies in Minnesota. On trees and rocks.

Type species *Biatorella roussellii* (Dur. & Mont.) De Not. loc. cit.

KEY TO THE SPECIES.

- Spores spherical..... 1. *B. moriformis*.
 Spores oblong-ellipsoid.
 Apothecia pruinose 2a. *B. simplex pruinosa*.
 Apothecia not pruinose.
 Apothecia small or minute, adnate..... 2. *B. simplex*.
 Apothecia middle-sized, loosely sessile or sub-
 stipitate 3. *B. clavus*.

1. ***Biatorella moriformis*** (Ach.) Th. Fr. Lich. Scand. 2: 401. 1874.

Arthonia moriformis Ach. Syn. Meth. Lich. 5. 1814.

Thallus composed of very minute granules, these commonly compacted into a thin, smooth, or more or less leprose or chinky crust, sea-green or more commonly whitish or rarely brownish, widely spread over the substratum or disappearing entirely; apothecia small or minute, 0.2 to 4 mm. in diameter, adnate, flat to slightly convex, pale brownish to brown and finally black; exciple evanescent or entirely absent; hypothecium pale; hymenium pale throughout or brownish above; paraphyses commonly simple and somewhat enlarged and brownish above, somewhat gelatinized and indistinct; asci clavate or ventricose; spores spherical, very minute, 1.5 to 2.5 μ in diameter, numerous in the asci.

Collected at Warroad and Tower. On cedars. A rare lichen in the State and also for North America.

Known elsewhere in North America in Massachusetts and Washington, and at Lake Manitoba and Lake Winnepegosis. Known also in Europe.

Biatora moriformis of the preliminary reports.

2. *Biatorella simplex* (Dav.) Br. & Rostr. Bot. Tidssk. 3: 241. 1869.

Lichen simplex Dav. Trans. Linn. Soc. Lond. 2: 283. pl. 28. f. 2. 1794.

Thallus deficient and seldom seen; apothecia small or minute, 0.2 to 0.8 mm. in diameter, adnate, scattered or crowded into dense clumps, rounded or becoming variously irregular, the disk dark red or black, the thin exciple persistent, raised and black; hypothecium cloudy or brownish; hymenium pale; paraphyses slender, simple or rarely branched, frequently somewhat thickened and brownish toward the apex; asci cylindrical or cylindrico-clavate; spores oblong-ellipsoid, minute, 3 to 5 μ long and 1 to 1.5 μ wide, very numerous in the asci.

Found in the southern half of the State wherever limestone occurs and as far to the northwest as Leaf Hills and Battle Lake. On limestones.

Widely distributed in the United States and as far north as Newfoundland. Known in all of the grand divisions except South America.

Lecanora privigna is the synonym of the preliminary reports.

2a. *Biatorella simplex pruinosa* (J. E. Smith) Fink.

Lichen pruinus J. E. Smith in Sowerby, Engl. Bot. 32: pl. 2244. 1811.

Thallus thin and perhaps as deficient as in the last; apothecia more closely appressed or even more or less immersed in the substratum, the disk more or less pruinose, becoming rather larger, reaching 1 millimeter or more in diameter, otherwise externally and internally as the above.

Sometimes considered a distinct species, but certainly connected by intermediate forms with the *B. simplex*.

Occurring with the type and on the same substrata.

North American distribution about as of the last, but not found quite so far north. Found also in Europe and Africa.

Lecanora privigna pruinosa of the preliminary reports.

3. *Biatorella clavus* (Lam. & DC.) Th. Fr. Lich. Scand. 2: 409. 1874.

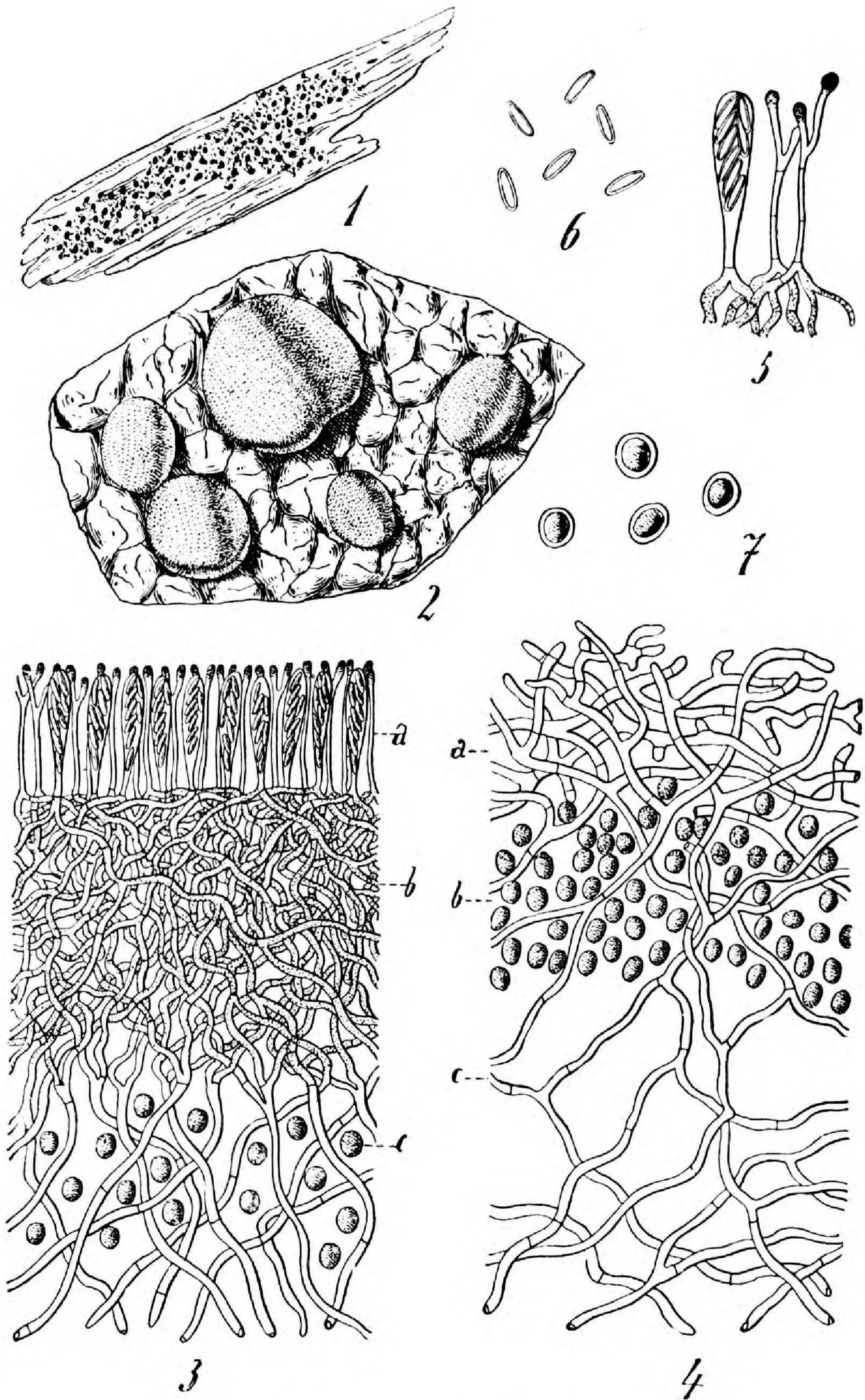
Patellaria clavus Lam. & DC. Fl. Fr. ed. 3. 2: 348. 1805.

Thallus as in the last, but perhaps more commonly present though indistinct; apothecia middle-sized or larger, 0.7 to 2 mm. in diameter, rather loosely sessile or substipitate, scattered or somewhat clustered, rounded or becoming wavy or variously irregular, the disk dark red or black, concave or becoming flat or even somewhat convex, the exciple thick, chinky and raised, or finally disappearing; hypothecium brown or blackening; hymenium pale or brownish; paraphyses simple or rarely branched, scarcely so slender as in the last, commonly enlarged and brownish or bluish toward the apex; asci cylindrico-clavate or ventricose; spores oblong-ellipsoid, minute, 4 to 6.5 μ long and 2 μ wide, thus on the whole larger than those of the last.

Sometimes considered a subspecies of the last, but ours seems distinct enough, as does all other material at hand.

The plant was collected on the sandstone at MacGregor, Iowa, and no doubt occurs on the same rocks along the Mississippi River in Minnesota.

Elsewhere in North America known from New England, West Virginia, Georgia, Kansas, and California. Known also in Europe.



LECIDEA MELANCHEIMA TUCK.

LECIDEA Ach. Meth. Lich. xxx, 32. *pl. 2. f. 1, 2.* 1803.

PLATE 4.

The thallus is crustose and variously granulose, verrucose, or areolate. Lichens with squamulose thalli have been admitted to the genus by many authors, but following our disposition of the poorly defined group *Biatora*, as admitted by Tuckerman, we have separated these. There are no definite layers of the thallus, except possibly in a very few species having rather thick thalli, and even in these there is no definite cortex. As is usual in such rudimentary thalli, hyphal rhizoids penetrate the substratum and serve as attaching organs. The algal symbionts are the common *Cystococcus*. The thallus is frequently evanescent.

The apothecia are small, or rarely reach middle size. They are commonly adnate or immersed, though sessile apothecia occur in some of the species. The disk varies from pale to black and is flat or convex. The proper exciple and the hypothecium vary from pale to dark brown in sections, the former often being black macroscopically. The spores are simple, hyaline, and usually oblong or ellipsoid, though some species have spores in part 2-celled.

The genus as above limited is closely related to *Megalospora*, and contains but a small proportion of the species placed in it by some lichenists. *Psora* has been excluded because of difference in thallus structure and *Biatorina*, *Bilimbia*, *Bacidia*, and *Biatorella* because of diversity of spore structure. The *Lecideas* represent a different line of evolution and are doubtless nearer the *Megalosporas* than are the *Bilimbias* and *Bacidias*.

Thirty-four species and subspecies have been found in the State. On trees, rocks, earth, old wood, and mosses.

Type species *Lecidea tigillaris* Ach. loc. cit. This plant is our *Acolium tigillare* (Ach.) De Not. Thus it would seem that *Lecidea* must be replaced by another name after the lichen genera have all been typified, and the substitute will probably be *Parmelia*.

EXPLANATION OF PLATE 4.—Fig. 1, plant. Fig. 2, apothecia and a portion of the thallus. Fig. 3, a section of an apothecium and part of the thallus; *a*, the hymenium; *b*, the hypothecium; *c*, the algal layer. Fig. 4, a section of the thallus; *a*, the pseudocortex of entangled hyphæ; *b*, the algal layers; *c*, the medullary layer. Fig. 5, paraphyses and an ascus. Fig. 6, free spores. Fig. 7, algal cells. Fig. 1, natural size; fig. 2, enlarged about 10 diameters; figs. 3, 4, enlarged 425 diameters; figs. 5, 6, 7, enlarged 650 diameters. From Schneider.

KEY TO THE SPECIES.

- Section I. Exciple and hypothecium softish and usually light-colored (*Biatora*).
 Parasitic on other lichens, no thallus of its own distinguishable..... 18. *L. oxyspora*.
 Not parasitic on other lichens.
 Thallus sea-green to ashy.
 Thallus areolate.
 Apothecia small or minute, disk pale flesh-color to black..... 1. *L. coarctata*.
 Apothecia larger; disk usually black..... 2. *L. brujeriana*.
 Thallus granular, or if areolate tardily so.
 Thallus tardily areolate or subareolate.
 Margin of the apothecium becoming flexuous; disk black and flat..... 4. *L. flexuosa*.
 Margin of the apothecium not flexuous.
 Disk flattish to strongly convex, pale brownish to black..... 10. *L. turgidula*.

- Disk flat or rarely somewhat convex,
dark brown to black..... 11. *L. panaeola*.
- Thallus granular, but never areolate or subareolate.
late.
- Thallus becoming chinky.
- Disk flat or somewhat convex, pale to reddish brown or black..... 6. *L. mutabilis*.
- Disk becoming very convex, pale yellowish to reddish brown or black... 7. *L. vernalis*.
- Thallus not chinky.
- Granules very minute; apothecia black..... 5. *L. viridescens*.
- Granules larger.
- Granules large; apothecia middle-sized, from flesh-color to olivaceous and black..... 3. *L. granulosa*.
- Granules middle-sized; apothecia small, rusty-brown, passing through sanguineous to black.. 8. *L. sanguineoatra*.
- Thallus not usually sea-green nor ashy.
- Thallus usually brown or brownish.
- Thallus forming an inconspicuous, evanescent crust; apothecia small or minute, pale flesh color and darkening..... 9. *L. carnulenta*.
- Thallus plainly granular, persistent.
- Thallus often tardily subareolate; apothecia small or minute, brown to black.... 13. *L. myriocarpoides*.
- Thallus never becoming subareolate.
- Thallus thicker, greenish-olivaceous to rusty-brown or darker; apothecia small or minute, brown or brownish black 12. *L. uliginosa*.
- Thallus thinner; apothecia and spores smaller than in the above..... 12a. *L. uliginosa fuliginosa*.
- Thallus greenish or yellowish.
- Thallus granular, tardily becoming chinky.
- Apothecia commonly flat, or becoming convex, very minute, pale yellowish to brown or black..... 14. *L. varians*.
- Apothecia commonly convex, twice as large as in the last, brown or black..... 15. *L. querneae*.
- Thallus granular, not becoming chinky.
- Apothecia olivaceous or black, minute... 16. *L. flavidolivens*.
- Apothecia pale lemon to brownish, small or minute..... 17. *L. lucida*.
- Section II. Exciple and hypothecium horny, usually dark-colored (Eulecidea).
On rocks.
- Thallus whitish or whitish ashy, becoming chinky and areolate; apothecia immersed or adnate, reaching middle size, black..... 24. *L. speirea*.
- Thallus ashy, sea-green, or rarely olivaceous.
- Thallus minutely scurfy-granular; apothecia minute, black..... 26. *L. cyrtidia*.

Thallus not plainly granular.

Thallus becoming more or less distinctly areolate.

Apothecia usually immersed.

Hypothecium pale..... 20. *L. cyanea*.

Hypothecium dark.

Thallus widely spread; apothecia small..... 19. *L. lapicida*.^a

Thallus usually covering quite limited rounded or irregular areas; apothecia middle-sized. 23. *L. lactea*.

Apothecia not usually immersed.

Apothecia adnate or somewhat immersed, commonly somewhat pruinose..... 25. *L. albocaerulescens*.

Apothecia sessile or adnate, rarely somewhat pruinose..... 27. *L. platycarpa*.

Thallus becoming chinky but not areolate, rarely subareolate.

Hypothecium pale; apothecia small, blackish, rarely pruinose..... 21. *L. lithophila*.

Hypothecium dark.

Disk flat, with persistent exciple, black..... 22. *L. contigua*.

Disk convex, exciple disappearing.. 22a. *L. contigua convexella*.

On trees or old wood (rarely on rocks).

Thallus rather thick, rough and verrucose; apothecia middle-sized, adnate, very black..... 29. *L. melancheima*.

Thallus thinner, smooth or becoming areolate or verrucose.

Thallus pale yellowish, verrucose..... 28a. *L. enteroleuca theioplaca*.

Thallus sea-green, ashy, or whitish.

Thallus becoming chinky, areolate, or verrucose.

Thallus becoming chinky or areolate..... 28. *L. enteroleuca*.

Thallus becoming verrucose or verrucose-areolate.

Thallus rather thick at first but often disappearing..... 28d. *L. enteroleuca pilularis*.

Thallus at first thin, becoming thicker..... 28b. *L. enteroleuca achricta*.

Thallus not usually becoming areolate or verrucose.

Thallus thin and smoothish, variegated by black lines..... 28c. *L. enteroleuca flava*.

Thallus thin and smoothish, not variegated by black lines..... 28e. *L. enteroleuca ambigua*.

^aSee also 19a. *L. lapicida oxydata*.

1. **Lecidea coarctata** (J. E. Smith) Nyl. Act. Soc. Linn. Bord. 21: 358. 1856.

Lichen coarctatus J. E. Smith in Sowerby, Engl. Bot. 8: pl. 534. 1799.

Thallus composed of minute, scattered or clustered, rounded, angular or minutely and irregularly crenate, sea-green, brownish, or more commonly ashy, sometimes squamaceous areoles 0.3 to 0.5 mm. in diameter, sometimes even passing into an areolate or subcontinuous and chinky crust; apothecia adnate, minute or small, 0.2 to 0.4 mm. in diameter, the disk commonly concave or flat and frequently difform, from pale flesh-color to black, sometimes having more or less of a thalloid exciple, or more commonly this disappearing and the structure becoming truly biatoroid; hypothecium pale to brownish; hymenium pale to yellowish or brownish; paraphyses slender, frequently branched, commonly thickened and darker toward the apex; asci clavate; spores ellipsoid or ovoid, 13 to 23 μ long and 7 to 10 μ wide.

On account of the sometimes present thalloid exciple the plant has often been referred to *Lecanora*, but its affinities on the whole are rather with the present genus. The plant is quite variable.

Collected at such remotely separate localities as Beaver Bay and Mankato and no doubt widely distributed in the State. On sandstone and igneous rocks. The plants from Mankato show the thalloid accessory exciple fairly well.

The plant is widely distributed in North America. Known in all of the grand divisions except Australia.

Biatora coarctata of the preliminary reports.

2. **Lecidea brujeriana** (Schaer.) Leight. Brit. Lich. 281. 1871.

Lecanora coarctata brujeriana Schaer. Enum. Lich. Eur. 77. 1850.

Thallus composed of minute verrucæ or granules or sometimes of larger areoles, scattered or clustered in a continuous or areolate crust, this quite thick and prominent or thin and finally disappearing, the color much as in the last, the structure on the whole coarser; apothecia adnate, becoming larger than in the last and in some forms here admitted even reaching 1 millimeter in diameter, concave, flat or convex, frequently clustered, the disk usually black, frequently bordered by a stout biatoroid exciple of the same color, but never with a thalloid exciple; hypothecium and hymenium more or less brownish; paraphyses simple or branched, enlarged and dark toward the tips; asci clavate, the apical wall thickened; spores ovoid-ellipsoid, 12 to 21 μ long and 6 to 10 μ wide. Regarded by Tuckerman as a subspecies of the last, but quite distinct.

Our plant as reported from Taylors Falls seems nearer the last, nor is our material from the only other known Minnesota locality, Mankato, as well defined as the rather smaller plant collected at La Crosse, Wisconsin, by L. H. Pammel. Both the last and all the Minnesota material on sandstone.

Tuckerman reports the species from sandstone in South Carolina. Known also in Europe.

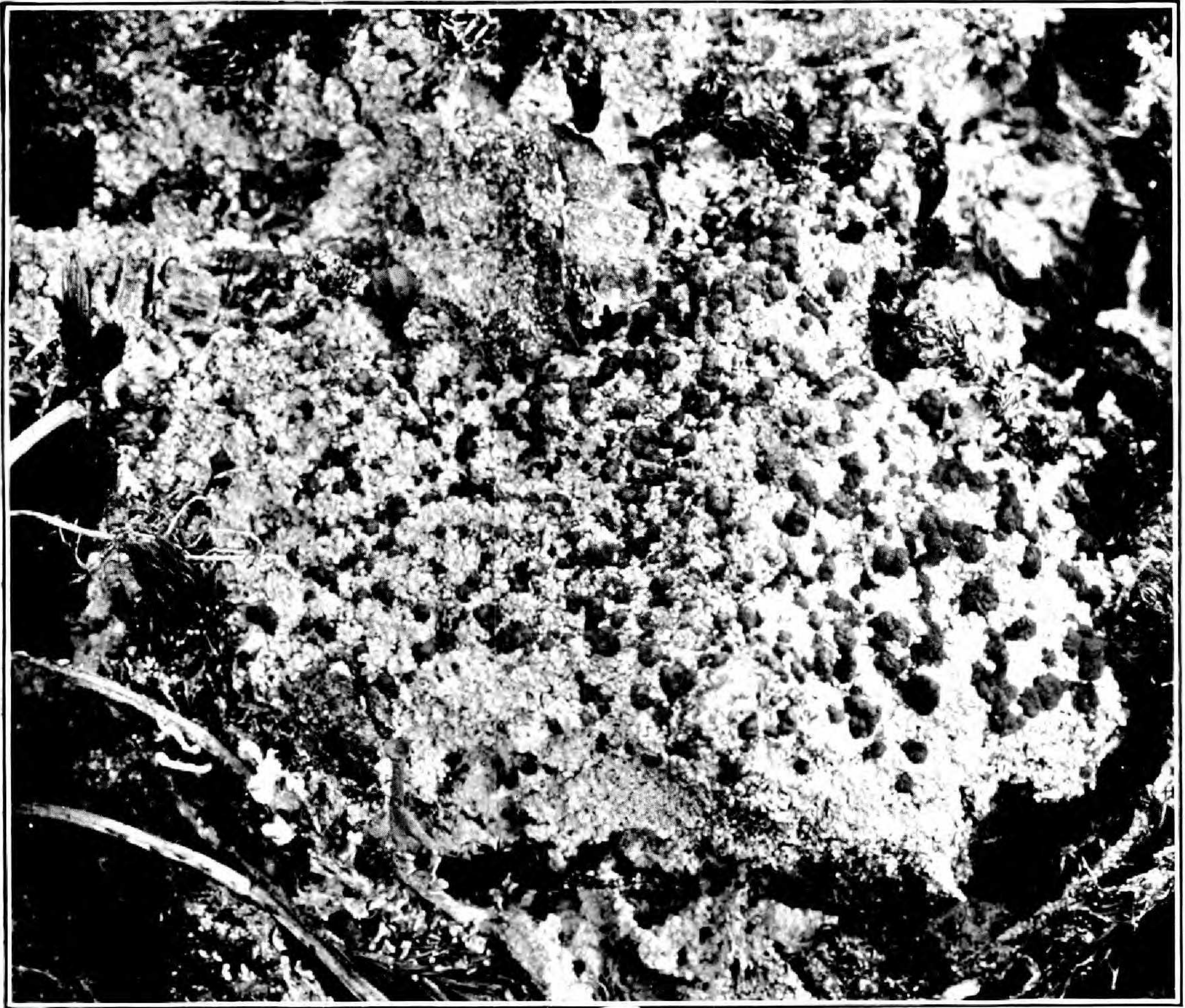
Biatora coarctata brujeriana of the preliminary reports.

3. **Lecidea granulosa** (Hoffm.) Ach. Meth. Lich. 65. 1803.

PLATE 5, A

Verrucaria granulosa Hoffm. Descr. Pl. Crypt. 2: 21. pl. 30. f. 3. 1794.

Thallus composed of hemispherical or irregular and sublobate, commonly densely aggregated and subimbricate, ashy or sea-green smooth granules, these 0.2 to 0.5 mm. in diameter, frequently bursting into greenish soeradiate heaps, for the most part widely spread over the substratum with clusters of apothecia here and there; the whole structure verrucose and, in the better developed conditions, more or less of a pseudo-cortex of gelatinized hyphæ to be made out above, the thallus being thus more highly developed than in any other of our members of the genus; apothecia reaching middle size, 0.3 to 1.5 or even 2 mm. in diameter, adnate, from flesh-colored to olivaceous and black, with an elevated and frequently lighter-colored margin, this commonly disappearing, leaving the disk convex and the apothecia as a whole irregular and fre-



A. *LECIDEA GRANULOSA* (HOFFM.) ACH.



B. *BACIDIA RUBELLA* (HOFFM.) MASS.

quently conglomerate; hypothecium pale brown; hymenium pale brownish or darker above; paraphyses rarely branched or enlarged toward the apex, frequently more or less gelatinized and coherent; asci cylindrico-clavate; spores ovoid-ellipsoid, 9 to 16 μ long and 4.5 to 7 μ wide.

The plant has been collected only on Blueberry Island in Lake of the Woods, at Koochiching and at Grand Marais, but doubtless occurs in southern Minnesota as it has been collected at McGregor, in Iowa, a short distance from the Minnesota line. On earth and on cedars in swamps.

Widely distributed in the northern United States, especially in mountains, and northward to arctic America. Known also in Europe.

Biatora granulosa of the preliminary reports.

EXPLANATION OF PLATE 5.—A, Plants of *Lecidea granulosa* on earth, showing the conspicuous apothecia and the granulose thallus. B, Plants of *Bacidia rubella* on smooth bark, showing the apothecia. A and B enlarged about $1\frac{1}{2}$ diameters.

4. *Lecidea flexuosa* (Fr.) Nyl. Act. Soc. Linn. Bord. 21: 356. 1856.

Biatora flexuosa Fr. Vet. Akad. Handl. 1822: 267. 1822.

Thallus composed of rather flattened or rugose granules, these smaller than those of the last, scattered or clustered and not infrequently forming an areolate crust, spreading widely over the substratum, sea-green varying to ashy, sometimes bursting into sorediate heaps; apothecia adnate, small or minute, 0.2 to 0.4 mm. in diameter, the thin livid or darker margin becoming very flexuous, the disk black and flat; hypothecium brown or brownish, the exciple commonly darker in section; hymenium pale brownish; paraphyses commonly simple, but somewhat gelatinized and indistinct in the material examined; asci cylindrico-clavate; spores oblong-ellipsoid, 7 to 10 μ long and 3 to 5 μ wide.

Collected at Granite Falls and at Harding, the material from the latter place being especially fine. On old wood.

Throughout the eastern United States and northward to Newfoundland. Known also in Europe and Africa.

Biatora flexuosa of the preliminary reports.

5. *Lecidea viridescens* (Schrad.) Ach. Meth. Lich. 62. 1803.

Lichen viridescens Schrad. Spic. Fl. Germ. 88. 1794.

Thallus composed of very minute, smooth or deliquescent and powdery granules, these 0.1 to 0.2 mm. in diameter and frequently widely spread over the substratum in a thin layer, ashy to greenish; apothecia frequently clustered and conglomerate, adnate, in ours small or minute, 0.2 to 0.4 mm. in diameter; margin of exciple of same color as in the last, but thinner and disappearing early as the black disk becomes convex; hypothecium pale brownish or brown; hymenium brownish or purplish; paraphyses rarely branched, thickened and darker toward the apex; asci clavate; spores oblong or ovoid, 9 to 13 μ long and 4 to 5.5 μ wide.

Collected in the Misquah Hills and at Bemidji. On old wood. Doubtless to be found at other places in the northern portion of the State.

Known elsewhere in North America in New Jersey, New England, Alaska, and on Cape Breton Island. Found also in Europe.

Biatora viridescens of the preliminary reports.

6. *Lecidea mutabilis* Fée, Mém. Mus. Hist. Nat. Strasb. 2^E: 105. 1835.

Thallus composed of small, closely contiguous granules, usually running together into a continuous and more or less chinky ashy-gray crust, in ours rather thin and covering somewhat rounded areas of substratum from 10 to 35 mm. in diameter, the chinky crust possibly sometimes becoming subareolate; apothecia small, or in ours even minute, 0.2 to 0.5 mm. in diameter, adnate, the disk flat or becoming convex,

pale to reddish brown, or in ours black, the thin exciple soon disappearing; hypothecium pale or yellowish; hymenium pale; paraphyses simple or rarely branched, seldom thickened or much darkened toward the apex; asci clavate or cylindrico-clavate; spores ovoid-ellipsoid, 13 to 16 μ long and 7 to 9 μ wide.

The plant referred to this species was collected at Warroad. On trees.

Elsewhere known in the United States from the extreme southern States. It continues southward through Mexico into South America. Known also in Europe and Africa.

Biatora mutabilis of the preliminary reports.

7. *Lecidea vernalis* (L.) Ach. Meth. Lich. 68. 1803.

Lichen vernalis L. Syst. Nat. ed. 12. 234. 1768.

Thallus composed of very minute, scattered or contiguous, ashy to sea-green, irregular or hemispherical granules, these about 0.1 to 0.2 mm. in diameter, commonly widely spread over the substratum as a more or less continuous layer, or when on wood sometimes becoming compacted into a smoother, less granular, chinky crust, usually quite thin; apothecia adnate, small, commonly 0.15 to 0.85 mm. in diameter, becoming very convex and the exciple disappearing, often clustered and even conglomerate, the disk from pale yellowish to reddish brown and even blackening; hypothecium pale brownish to brown; hymenium pale brownish; paraphyses simple or branched toward the apex, pale or brownish-tinged, the apex sometimes thickened; asci clavate; spores oblong-ellipsoid, 12 to 17 μ long and 4 to 6 μ wide, sometimes 2-celled.

Generally distributed over the northern portion of the State. On mosses, especially at the bases of trees, and also rarely on wood.

Distributed throughout the northern United States and northward to arctic America. Known in all of the grand divisions.

Biatora vernalis of the preliminary reports.

8. *Lecidea sanguineoatra* (Wulf.) Ach. Meth. Lich. 50. 1803.

Lichen sanguineoater Wulf. in Jacq. Coll. Bot. 3: 116. 1789.

Thallus composed of commonly closely aggregated and even heaped, sea-green or ashy-gray, irregular or subhemispherical granules, these somewhat larger than those of the last, 0.1 to 3.5 mm. in diameter, and like the last widely spread over the substratum, but forming a somewhat thicker layer, never becoming smooth and chinky or subareolate; apothecia adnate, somewhat larger than in the last; 0.20 to 1 mm. in diameter, flattish to strongly convex, the margin disappearing in the latter condition, the disk dark rusty-brown passing through sanguineous to black with age, scarcely so much inclined to the strongly convex condition as in the last, the apothecia also not as much inclined toward the clustered condition; hypothecium brown; hymenium pale brownish; paraphyses simple or branched toward the apex, there commonly thickened and brownish; asci clavate or cylindrico-clavate; spores ellipsoid, varying toward fusiform, the 2-celled condition of the last not seen, 9 to 18 μ long and 3.5 to 5.5 μ wide.

Sometimes considered a subspecies of the last, but ours at least seems distinct.

Distribution and habitats in Minnesota the same as of the last.

To be looked for in all portions of the United States and northward at least to Newfoundland and Alaska, thus on the whole somewhat more southern in its distribution than the last. Known also in Europe, Asia, and Africa.

Biatora sanguineoatra of the preliminary reports.

9. *Lecidea carnulenta* (Tuck.) Fink.

Biatora carnulenta Tuck. Proc. Amer. Acad. **12**: 179. 1877.

Thallus rudimentary or entirely disappearing; when present consisting of a very thin and usually scattered crust, this commonly sea-green to brownish in color and so inconspicuous as to appear only under a lens; apothecia small or minute, 0.2 to 0.6 mm. in diameter, flattish to convex, the disk pale flesh-colored and darkening, the exciple darker or disappearing, the disk sometimes faintly pruinose; hypothecium pale to pale-brownish; hymenium of the same color or darker above; paraphyses slender, simple or branched, sometimes enlarged and brownish toward the apex; asci clavate; spores ovoid-ellipsoid, 7 to 12 μ long and 3 to 5.5 μ wide.

Ours on the whole seems somewhat better developed than Tuckerman's plant and appears to have the apothecia rather darker externally and internally.

A single collection was made at Warroad. On dead wood. The plant has been collected in northern Iowa and no doubt exists in other portions of Minnesota, but it is scarcely noticeable except under a lens and is usually overlooked.

A North American lichen, previously known from New England, New York, Illinois, and Iowa.

Biatora carnulenta of the preliminary reports.

10. *Lecidea turgidula* Fr. Sched. Crit. Lich. Exsicc. Suec. **1: 10. 1827.**

Thallus composed of minute, commonly more or less scattered, whitish to sea-green, irregular and commonly inconspicuous granules, these running together into a sub-continuous or subareolate and very thin crust or sometimes entirely disappearing; apothecia small to minute, 0.2 to 0.8 mm. in diameter, flattish to strongly convex, the exciple commonly absent, the disk from pale brownish to black, sometimes more or less white-pruinose; hypothecium brown; hymenium pale brownish; paraphyses simple or branched, slightly enlarged and brownish toward the apex; asci clavate; spores oblong to ellipsoid, 6 to 12 μ long and 3 to 5.5 μ wide.

Distributed throughout the northern portion of the State, apparently more common westward. On dead wood. Our Minnesota forms of the last two above seem very closely related, but both exist in the State, sometimes confusingly similar. Throughout northern United States and northward to arctic America. Known also in Europe and Asia.

Biatora turgidula of the preliminary reports.

11. *Lecidea panaeola* Ach. Lich. Univ. 201. 1810.

Thallus composed of minute, somewhat raised and irregular, scattered or contiguous, ashy-gray granules, these frequently running together into a verrucose or areolate crust of moderate thickness and often widely spread over the substratum, the areoles or verrucæ 0.15 to 0.3 mm. in diameter; apothecia rather small, 0.3 to 1 mm. in diameter, adnate or somewhat immersed, dark brown to black, almost constantly the latter in ours, the exciple of the same color in ours, the disk flat or rarely somewhat convex; hypothecium pale or pale brownish; hymenium pale below and darkened above; paraphyses simple or rarely branched, frequently somewhat colored and thickened toward the apex; asci clavate; spores oblong-ellipsoid, 11 to 16 μ long and 6 to 8.5 μ wide.

Biatora leucophaea is the synonym under which the plant was recorded in the preliminary survey, where also a subspecies was recorded from Grand Portage, which evidently belongs elsewhere, though indeterminable from the material at hand. The spores are rather large in our plant and the apothecia internally and externally inclined to darker conditions.

Distributed throughout the northern portion of the State. On rocks.

Previously reported from arctic America. Known also in Europe and New Zealand.

12. *Lecidea uliginosa* (Schrad.) Ach. Meth. Lich. 43. 1803.

Lichen uliginosus Schrad. Spic. Fl. Germ. 88. 1794.

Thallus composed of scattered, clustered or even more or less heaped, irregular and very minute, greenish-olivaceous to rusty brown or even blackish, somewhat raised granules, these forming a widely scattered, frequently subleprose, subcontinuous or scattered crust; apothecia small or minute, 0.2 to 0.35 mm. in diameter, closely appressed or rarely more or less immersed, often clustered, brown or brownish black, the disk flat or rarely somewhat convex, the exciple thin, raised and lighter-colored, but becoming black and disappearing; hypothecium light or darker brown; hymenium yellowish or brownish; paraphyses simple or branched, slender, usually enlarged and brownish toward the apex; asci long-clavate; spores ovoid-ellipsoid, 8 to 15 μ long and 4.5 to 8 μ wide.

Distributed throughout the northern portion of the State and also collected as far south as Mankato and New Ulm. On earth and old wood.

Widely distributed in North America. Known also in Europe and Asia.

Biatora uliginosa of the preliminary reports.

12a. *Lecidea uliginosa fuliginea* (Ach.) Leight. Lich. Fl. Great Brit. ed. 3. 274. 1879.

Lecidea fuliginea Ach. Syn. Lich. 35. 1814.

Thallus on the whole rather less developed and the apothecia smaller; spores 6 to 9 μ long and 3.5 to 5 μ wide. The species is quite variable, and some half dozen subspecies are recognized in Europe.^a

Collected once in the State, at Beaudette. On an old Polyporus. Listed in the seventh preliminary report as a distinct species.

Not found reported from other portions of the Western Hemisphere, though no doubt to be looked for with the species. Well known in Europe and found also in Asia.

13. *Lecidea myriocarpoides* Nyl. Flora 48: 355. 1865.

Thallus composed of minute, irregular, and somewhat flattened or more rarely hemispherical, olivaceous-brown granules, 1.5 to 3 mm. in diameter, forming a continuous, usually rather thin, subleprose or rarely even subareolate, widespread crust, this liable to become scattered or obsolete; apothecia small or minute, 0.15 to 0.4 mm. in diameter, adnate, dark brown to black, flat or becoming convex and turgid, and the thin black exciple disappearing; hypothecium brown or blackish brown; hymenium pale, brownish or bluish; paraphyses somewhat gelatinized, simple or rather rarely branched, sometimes enlarged and darker toward the apex; asci clavate; spores ellipsoid, 6 to 9 μ long and 2.5 to 4 μ wide.

Generally distributed over the State. On dead wood, especially fences, and also on rocks. Dr. T. Hedlund has referred our rock specimens to *Lecidea sylvicola* Flot.^b but ours are all alike so far as we can determine. Possibly the older name should be adopted, but we await further studies.

From Minnesota and Iowa eastward throughout the eastern United States. Known also in Europe.

Biatora myriocarpoides of the preliminary reports.

^a Cf. Hedlund, Bih. Svensk. Vet. Akad. Handl. II 18^m: 72. 1892.

^b Lich. Sil. Exsicc. no. 171. 1829. Cf. Koerb. Syst. Lich. 254. 1855.

14. *Lecidea varians* Ach. Syn. Meth. Lich. 38. 1814.

FIGURE 10.

Thallus composed of very minute, irregular, raised or more or less flattened, pale yellowish or greenish granules, these running together to form a continuous, commonly thin, smooth or more or less granulate-rugose and often chinky crust, this more commonly somewhat orbicular and 7 to 20 mm. in diameter, usually bordered and sometimes decussate by black lines (the so-called hypothallus); apothecia adnate, very minute, 0.12 to 0.25 mm. in diameter, commonly flat, with a thin exciple, which soon disappears, the apothecia then becoming convex, often clustered and conglomerate, from pale yellowish varying to brown and finally black, said to be rarely white-pruinose; hypothecium pale or yellowish; hymenium pale below and frequently brownish or pale blue-violet above; paraphyses simple, the apex commonly enlarged and partaking of the color of the upper hymenium; asci clavate; spores ovoid-ellipsoid, 7 to 15 μ long and 5 to 7.5 μ wide.

Generally distributed over the State, but easily overlooked. On trees and old wood. A very variable plant.

Generally diffused over North America. Known also in Europe and Africa.

Biatora varians of the preliminary reports.

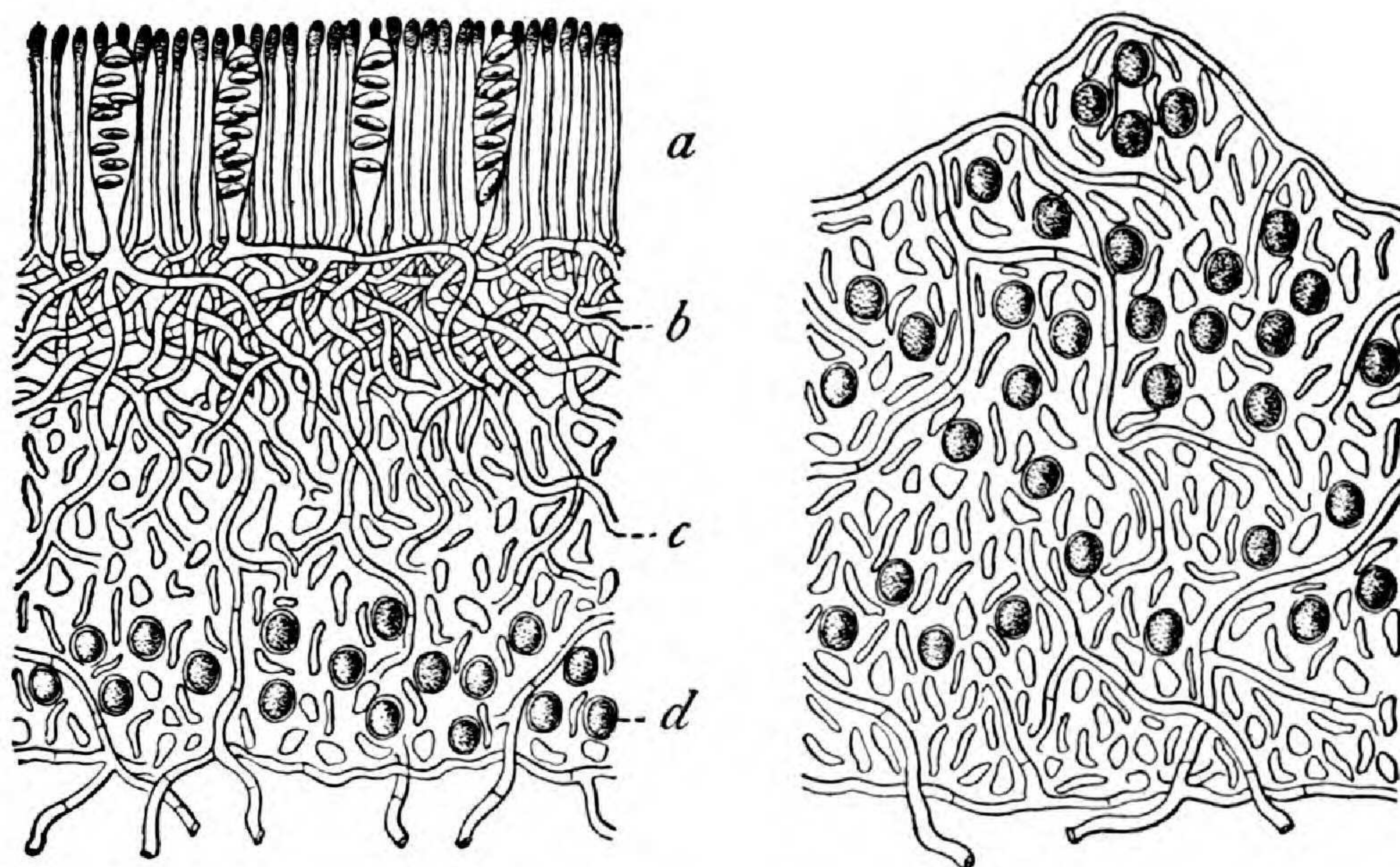


FIG. 10.—*Lecidea varians*, showing at the right a section of the rudimentary thallus and at the left a section of a portion of an apothecium. *a*, The hymenium; *b*, *c*, the hypothecium; *d*, the algal layer below the apothecium. Enlarged 300 diameters. From Schneider.

15. *Lecidea quernea* (Dicks.) Ach. Meth. Lich. 62. 1803.

Lichen querneus Dicks. Pl. Crypt. Brit. 1: 9. pl. 2. f. 3. 1785.

Thallus composed of small, usually more or less scattered, greenish, yellowish, or brownish granules, sometimes running together to form a thin, chinky crust, more or less widely spread over the substratum; apothecia adnate or immersed, small or minute, 0.3 to 1 mm. in diameter, commonly convex and becoming irregular in form, brown to black in color or slightly whitish-pruinose in some of ours, the exciple evanescent; hypothecium pale or brownish; hymenium pale; paraphyses more or less gelatinized and coherent-indistinct; asci clavate or cylindrico-clavate; spores ovoid-ellipsoid, 6 to 11 μ long and 4 to 7 μ wide.

Collected along the northern boundary at Warroad and at Rainy Lake City. On dead wood.

Elsewhere in North America in California. Known also in Europe.

Biatora quernea of the preliminary reports.

16. Lecidea flavidolivens (Tuck.) Fink.

Biatora flavidolivens Tuck. Syn. N. A. Lich. **2**: 28. 1888.

Thallus composed of minute, irregular, and usually crowded and heaped, greenish to yellowish brown granules, these forming a commonly widespread continuous or somewhat scattered crust; apothecia minute, olivaceous to black in ours, 0.2 to 0.3 mm. in diameter, adnate or immersed, flat, with a pale exciple, or becoming convex and the exciple disappearing; hypothecium brownish or brown; hymenium pale or pale bluish; paraphyses simple, but more or less gelatinized and coherent; asci broadly clavate; spores simple or rarely 2-celled, 7 to 14 μ long and 3 to 4 μ wide.

Collected at Warroad. On a cedar stump in a swamp. The plant so reported from Rat Lake seems nearer the next. Tuckerman's plant had not the black apothecia and its spores are somewhat larger.

A North American lichen, elsewhere only known at New Bedford, Massachusetts.

Biatora flavidolivens of the preliminary reports.

17. Lecidea lucida Ach. Meth. Lich. 74. 1803.

Lichen lucidus Ach. Lich. Suec. 39. 1798.

Thallus composed of minute granules commonly breaking up into a fine, powdery crust, this usually widely spread over the substratum as a greenish yellow, continuous or more or less scattered, rather thin layer, or rarely more or less collected into little heaps; apothecia adnate, small to minute, 0.15 to 0.35 mm. in diameter, more or less convex, pale or darker lemon-color, passing into brownish, sometimes clustered or conglomerate, the exciple evanescent; hypothecium and hymenium pale yellowish; paraphyses commonly simple, but somewhat gelatinized, coherent and indistinct; asci clavate; spores oblong-ovoid, 4 to 7 μ long and 2 to 3 μ wide.

Widely distributed in northern Minnesota. On shaded rocks.

Elsewhere in North America known from New York, Massachusetts, and arctic America. Found also in Europe.

Biatora lucida of the preliminary reports.

18. Lecidea oxyspora (Tul.) Nyl. Act. Soc. Linn. Bord. **21**: 391. 1856.

Abrothallus oxysporus Tul. Ann. Sci. Nat. Bot. III. **17**: 116. *pl.* 16. *f.* 27. 1852.

Thallus evanescent or not distinguishable from that of the host, the latter deformed by the parasite and passing into small tufts of irregular or cucullate lobules; apothecia minute, 0.15 to 0.3 mm. in diameter, flattish or slightly convex, more or less immersed in the deformed thallus of the host, pale brown to black, without exciple; hypothecium pale brownish to brown; hymenium pale throughout or brownish above; paraphyses usually simple, commonly enlarged and brownish toward the apex; asci clavate; spores ellipsoid to fusiform, 15 to 20 μ long and 5 to 7.5 μ wide.

Generally distributed throughout the northern portion of the State. On Parmelias and especially common on *P. borreri* on cedars in swamps.

Known elsewhere in North America from New England, Canada, and Ontario. Found in all of the grand divisions except Africa.

Biatora oxyspora of the preliminary reports.

19. Lecidea lapicida Fr. Lich. Eur. 306. 1831.

Thallus more or less roughened, verrucose to areolate, sea-green or becoming more or less ash-colored, the areoles or verrucae about 0.5 to 1.75 mm. across, irregularly and often quite widely spread over the substratum as a rather thin crust; apothecia small, 0.3 to 1 mm. in diameter (said to become middle-sized), adnate or more or less immersed, sometimes clustered, the disk black and commonly flat, but frequently becoming convex and irregular, the exciple black and raised or finally disappearing; hypothecium usually dark brown; hymenium pale or more or less bluish below and darker above; paraphyses simple or rarely branched toward the commonly enlarged and darker apex; asci clavate; spores short-ellipsoid, 8 to 12 μ long and 4 to 7 μ wide.

Collected in the northern part of the State at Emo, at Rainy Lake City, and in the Misquah Hills. On rocks.

Elsewhere in North America in California and several localities in British America, extending northward to arctic America. Known also in Europe and New Zealand.

19a. *Lecidea lapicida oxydata* Tuck. Syn. N. A. Lich. 2: 70. 1888.

Thallus becoming rust-red.

The plant was collected at Grand Portage. On rocks.

Elsewhere in North America in California. Known also in Europe.

20. *Lecidea cyanea* (Ach.) Th. Fr. Lich. Scand. 2: 489. 1874.

Lecidea lapicida cyanea Ach. Meth. Lich. 38. 1803.

Thallus more or less roughened, chinky-areolate, sea-green, varying toward ashy, occurring in rounded areas or more widely and irregularly spread over the substratum, the verrucæ about 0.5 to 1.25 mm. across; apothecia often reaching middle size, in ours only 0.3 to 0.6 mm. in diameter, adnate and more commonly immersed, the disk black and flat, the exciple black and persistent; hypothecium pale or finally pale brownish; hymenium pale; paraphyses simple or rarely branched, commonly enlarged and darker toward the apex; asci clavate; spores ellipsoid, 8 to 12 μ long and 4 to 7 μ wide.

Collected at Pipestone; not previously reported from Minnesota. On pipestone.

Elsewhere in North America from New England, Florida, Nebraska, South Dakota, Oregon, California, and throughout British America. Known also in Europe and South America.

Lecidea tessellata of Tuckerman's Synopsis.

21. *Lecidea lithophila* Ach. Syn. Meth. Lich. 14. 1814.

Lecidea lapicida lithophila Ach. Lich. Univ. 160. 1810.

Thallus at first smoothish, but becoming more or less chinky, ashy or sea-green, sometimes disappearing, ours suborbicular or more or less irregularly spread over the substratum, the more regular thalli 30 to 50 mm. in diameter; apothecia small to minute in ours, 0.25 to 0.9 mm. in diameter, sometimes clustered and more or less angular, the disk black or blackish brown, commonly flat or only slightly convex, rarely somewhat pruinose, the exciple lighter-colored and seldom disappearing; hypothecium pale and finally pale brownish; hymenium pale throughout or darker above; paraphyses simple or rarely branched, somewhat coherent, frequently enlarged and darker toward the apex; asci clavate; spores oblong-ellipsoid, 11 to 15 μ long and 6 to 7 μ wide.

Collected on rocks at Grand Portage. Not previously reported from Minnesota.

Not known elsewhere in North America. Well known in Europe, and found also in Asia.

22. *Lecidea contigua* Fr. Sched. Crit. Lich. Exsicc. Suec. 13: 14. 1827.

Thallus more or less roughened, becoming somewhat chinky and finally subareolate, sea-green, and finally more or less ashy, irregularly spread over the substratum, sometimes thin and somewhat scattered; apothecia small to middle-sized, 0.5 to 1.5 mm. in diameter, from more or less immersed becoming adnate and sessile, the disk black and flat or finally convex, the exciple rather thin, black, and persistent; hypothecium dark brown; hymenium pale or brownish; paraphyses simple or not rarely branched, commonly thickened and brownish toward the apex; asci clavate or narrowly clavate; spores ovoid-ellipsoid, 10 to 16 μ long and 5 to 7 μ wide.

Collected on Grand Portage Island. On rocks.

Found in New England, New York, Pennsylvania, and Florida, and in various portions of British America. Known in all of the grand divisions.

Lecidea crustulata of the preliminary reports. The two names sometimes occur in the same list of lichen species, and they may yet prove to represent two distinct species.

22a. *Lecidea contigua convexella* (Wainio) Fink.

Lecidea crustulata convexella Wainio, Act. Soc. Faun. Flor. Fenn. **10**: 74. 1883.

Form with apothecia commonly becoming convex and the exciple disappearing.

Collected at Grand Marais and not previously reported from Minnesota. On rocks.

Not known elsewhere in North America. Found also in Europe.

23. *Lecidea lactea* (Flot.) Schaer. Lich. Helv. Spic. **3: 127. 1828.**

Lecidea petraea lactea Flot. Flora **2**: 692. 1828.

Thallus ashy, varying toward whitish or sea-green, of moderate thickness, at first smooth, but becoming more or less roughened and chinky or areolate, suborbicular or somewhat irregular, commonly 35 to 75 mm. across, forming a continuous layer and sometimes becoming thicker in ours; apothecia small to middle-sized or larger, 0.4 to 2.5 mm. in diameter, immersed or rarely becoming adnate, the disk black and commonly flat, the exciple thin and frequently disappearing; hypothecium brown or brownish; hymenium pale or pale brownish below and somewhat darker above; paraphyses commonly simple, frequently more or less coherent, sometimes enlarged and darker above; asci clavate or cylindrico-clavate; spores ellipsoid, 9 to 14 μ long and 4 to 6 μ wide.

Collected at several localities on the north shore of Lake Superior. On rocks.

Apparently not reported elsewhere in North America. Known in all of the grand divisions.

24. *Lecidea speirea* Ach. Meth. Lich. 52. 1803.

PLATE 6, A.

Lichen speireus Ach. Lich. Suec. 59. 1798.

Thallus white, or whitish-ashy and sometimes mealy, smoothish and chinky or becoming areolate or subareolate, scarcely as thick as that of the last above, usually in smaller patches than in the last and commonly irregular, about 15 to 50 mm. across, sometimes becoming rougher; apothecia small in ours, but said to reach more than middle size, immersed or becoming adnate, the disk black and commonly flat, but sometimes finally convex, the exciple black or whitish-pruinose, frequently disappearing; hypothecium brown or dark brown; hymenium commonly pale below and darker above; paraphyses commonly simple, frequently more or less coherent, commonly enlarged and darker toward the apex; asci clavate; spores ellipsoid, 9 to 14 μ long and 5 to 8 μ wide.

Collected with the last along the north shore of Lake Superior, where the two occur on the rocks, usually from the water line back not more than 5 meters.

Known in New England and from the north shore of Lake Superior in Ontario. Found also in Europe and Africa.

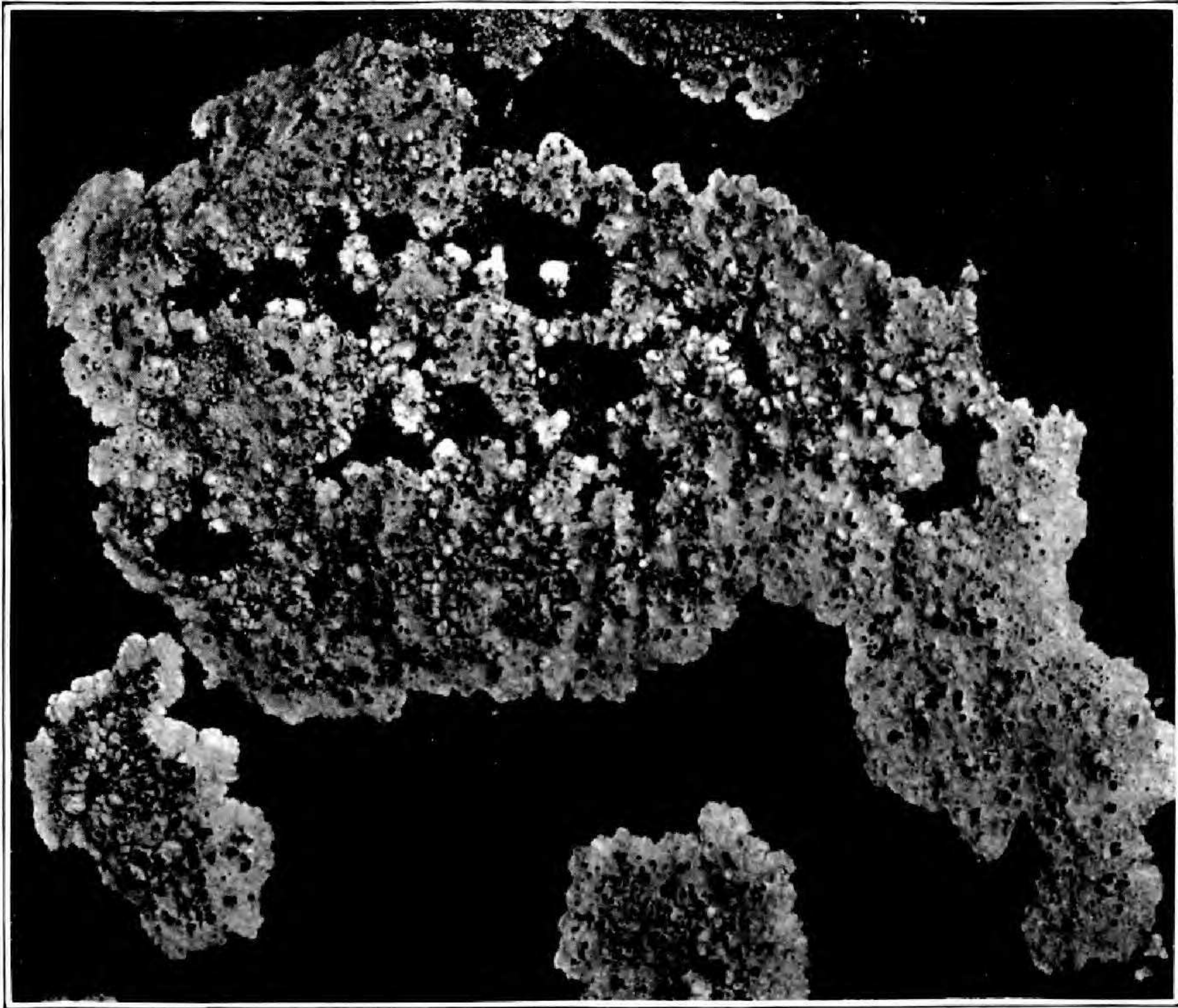
EXPLANATION OF PLATE 6.—A, Plants of *Lecidea speirea* on rocks, showing the thallus and the apothecia. B, Plants of *Lecidea albocaerulescens* on rocks, showing the crustose thallus and the apothecia. A enlarged 1½ diameters; B natural size.

25. *Lecidea albocaerulescens* (Wulf.) Schaer. Lich. Helv. Spic. **3: 142. 1828.**

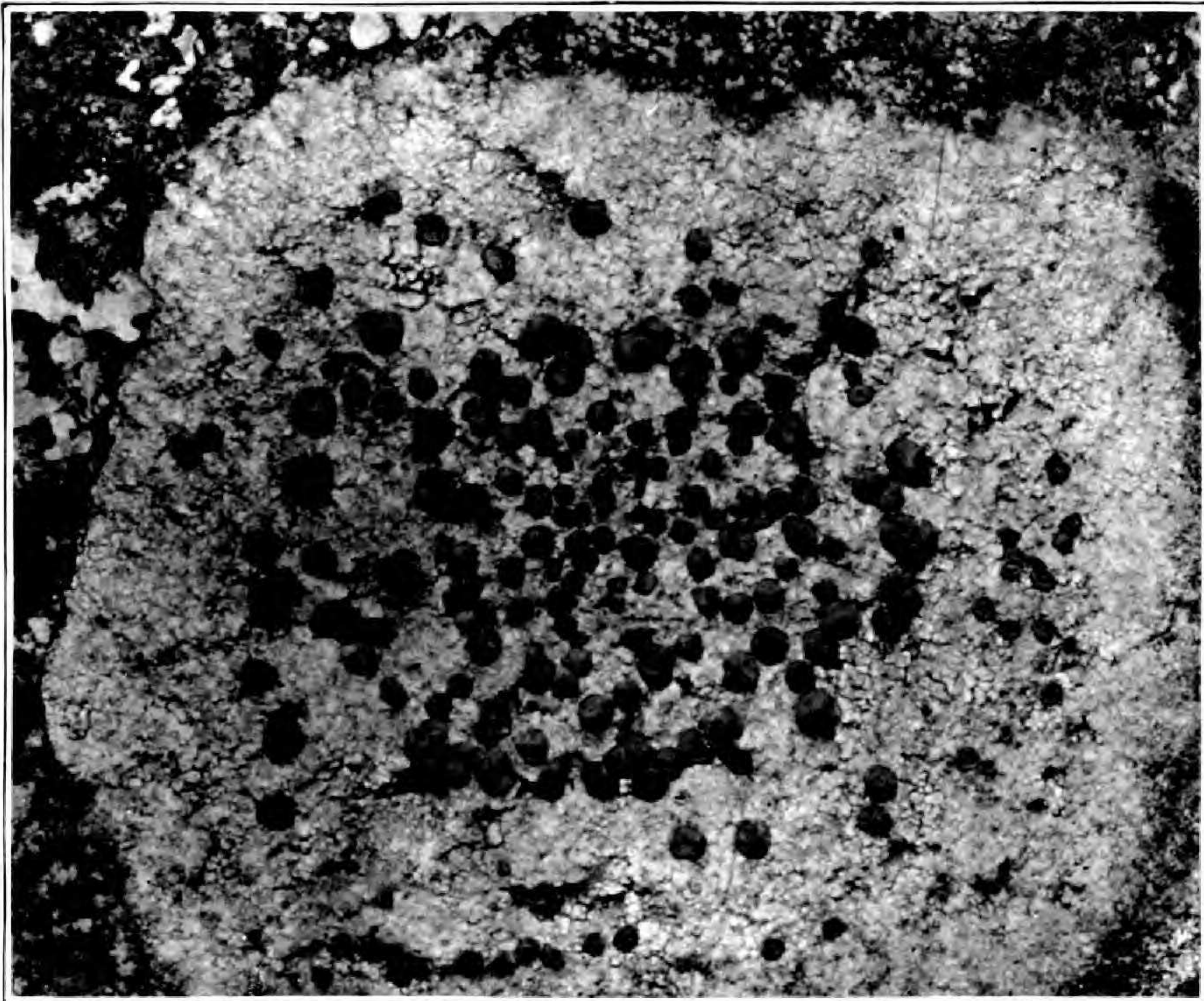
PLATE 6, B.

Lichen albocaerulescens Wulf. in Jacq. Coll. Bot. **2**: 184. pl. 15. f. 1. 1788.

Thallus commonly thinner than those of the last two, rather smoothish, more or less chinky and sometimes becoming obscurely small-areolate, ashy or varying toward whitish, sea-green or even olivaceous, spread over the substratum as a continuous crust, suborbicular or irregular and often covering quite large areas; apothecia small to middle-sized, 0.5 to 1.5 mm. in diameter, or 2 mm. or more in foreign material, adnate or rarely somewhat immersed, rounded or becoming irregular, the disk black or brownish black, usually flat, almost always more or less whitish-pruinose, the exciple black, seldom if ever disappearing; hypothecium brown to brownish black; hymenium commonly pale; paraphyses simple or rarely branched, somewhat coherent, commonly enlarged and darker toward the apex; asci clavate or inflated-clavate; spores ovoid-ellipsoid, 15 to 24 μ long and 7 to 10 μ wide.



A. *LECIDEA SPEIREA* ACH.



B. *LECIDEA ALBOCAERULESCENS* (WULF.) SCHAER.

Collected at Taylors Falls and in the Misquah Hills. On rocks.

Found in the Appalachian Mountains from Alabama northward as far as Newfoundland and in Alaska. Known also in Europe and Asia.

26. *Lecidea cyrtidia* Tuck. Proc. Amer. Acad. 12: 181. 1877.

Thallus composed of very minute scattered or sometimes crowded, scurfy granules, sea-green or more commonly varying toward greenish or olivaceous, the whole structure very inconspicuous and irregularly, frequently widely, spread over the substratum; apothecia also minute and closely adnate (so that the plant is frequently difficult to detect), 0.2 to 0.5 mm. in diameter, the disk black, at first flat but soon becoming convex, the exciple thick and black, but soon disappearing; hypothecium rather thick, pale, or more commonly brown; hymenium pale below and brownish above; paraphyses simple or rarely branched, sometimes more or less coherent, commonly enlarged and brownish toward the apex; asci clavate; spores ovoid-ellipsoid, 5 to 9 μ long and 2 to 4 μ wide.

Collected near Snowbank Lake and at Rainy Lake City, thus on or near the northern boundary. On rocks.

A North American species known in New England, Illinois, and Missouri.

27. *Lecidea platycarpa* Ach. Lich. Univ. 173. *pl. 2. f. 5.* 1810.

Thallus thin, more or less chinky and finally subareolate, sometimes becoming wrinkled, sea-green to ashy, or tinged red by iron, irregularly spread over the substratum as a continuous or more commonly as a more or less broken crust, and frequently for most part or entirely disappearing; apothecia small to middle-sized or even larger, 0.5 to 1.5 mm. in diameter, or larger in foreign specimens, usually scattered, sessile or adnate, the disk flat or becoming somewhat convex, black or brownish, rarely slightly pruinose, rounded or becoming somewhat irregular, the exciple thickish and becoming more or less flexuous and disappearing; hypothecium thick and blackish brown; hymenium pale below and pale brownish above; paraphyses simple or rarely branched, commonly somewhat enlarged and brownish toward the apex; asci clavate; spores ovoid-ellipsoid, 11 to 18 μ long and 5 to 9 μ wide.

Reported from the Misquah Hills and from Blueberry Island in Lake of the Woods, though the material from the former locality will doubtless have to be placed elsewhere eventually. On rocks.

Elsewhere in North America in New England, New York, Virginia, North Carolina, Ohio, and South Dakota. Known also in South America and Europe.

28. *Lecidea enteroleuca* Ach. Lich. Univ. 177. 1810.

Thallus commonly rather thin, smoothish, or more often variously chinky, areolate; the granules or verrucæ rarely becoming heaped and the thallus then thicker, this sea-green varying toward ashy, suborbicular, or variously irregular and more widely spread over the substratum, the more rounded thalli commonly 15 to 65 mm. across; apothecia minute to scarcely middle-sized, 0.3 to 1 mm. in diameter in ours, adnate, the disk black and soon becoming more or less convex, the exciple soon flexuous and disappearing; hypothecium pale to dark brown; hymenium pale below and more or less darkened above; paraphyses simple or sometimes branched, frequently more or less coherent, usually enlarged and brownish toward the apex; asci clavate, the apical wall more or less thickened; spores ovoid-ellipsoid, 8 to 17 μ long and 5 to 9 μ wide.

Generally distributed over the State, and often appearing as one of the subspecies below. On trees, old wood, and various rocks.

Distributed throughout North America. Known also in all of the grand divisions.

28a. *Lecidea enteroleuca theioplaca* Tuck. Gen. Lich. 179. 1872.

Thallus verrucose, pale yellowish; hypothecium dark and blackening; thallus with a greenish yellow cast in ours.

Collected at Harding on the northern boundary of the State. On rocks.

A north American subspecies, known also from New Jersey, South Carolina, Iowa, and California.

28b. *Lecidea enteroleuca achrista* (Sommerf.) Tuck. Syn. N. A. Lich. **2**: 80. 1888.

Lecidea elaeochroma achrista Sommerf. Suppl. Fl. Lapp. 150. 1826.

Thallus at first thin and smoothish, but becoming chinky or verrucose, whitish or rarely becoming dark-ashy; apothecia more inclined to remain flat and often becoming flexuous; hypothecium brownish yellow.

Collected at Grand Portage, Granite Falls, Battle Lake, and Red Lake. On trees.

Throughout the United States and northward into British America. Known also in Europe.

28c. *Lecidea enteroleuca flavida* Fr. Vet. Akad. Handl. **1822**: 261. 1822.

Thallus thin and smoothish, limited and variegated by black lines; apothecia sometimes with a thin gray bloom; hypothecium yellow to brownish black.

Collected at several points in the northwestern portion of the State. On trees.

Found elsewhere in North America in New England and Alaska. Known also in Europe.

28d. *Lecidea enteroleuca pilularis* (Dav.) Th. Fr. Lich. Scand. **2**: 543. 1874.

Lichen pilularis Dav. Trans. Linn. Soc. Lond. **2**: 283. 1794.

Thallus verrucose or areolate-verrucose, sea-green varying toward ashy, or even whitish, the verrucæ frequently scattered or disappearing; hypothecium pale (or sometimes brownish in ours).

Collected at Koochiching, at Tower, and on Flag Island in Lake of the Woods.

Elsewhere in North America on the Rideau River and at Aylmer in Canada. Well known in Europe.

Lecidea goniophila of the preliminary reports. In determining this again from the St. Peter sandstone at Minneapolis, the eminent authority, Dr. T. Hedlund, insists that *L. goniophila* (Floerke) Koerb, is distinct from *L. enteroleuca* Ach. We let the above disposition stand with this note, though Doctor Hedlund's disposition is to be respected.

28e. *Lecidea entroleuca ambigua* (Mass.) Tuck. Syn. N. A. Lich. **2**: 80. 1888.

Biatora ambigua Mass. Ric. Lich. 124. f. 242. 1852.

Thallus thin and smoothish; apothecia brownish flesh-colored to blackish and thinly pruinose; hypothecium as above.

Collected at several points in the northwestern portion of the State. On old wood.

Elsewhere in North America in Washington and Oregon. Known also in Europe.

29. *Lecidea melancheima* Tuck. Syn. Lich. N. E. 68. 1848.

PLATE 4.

Thallus thicker, rough, wrinkled and verrucose, sea-green or ashy, usually irregularly spread over larger or smaller areas of the substratum, at first as a continuous crust, but the verrucæ becoming more or less scattered and finally tending to disappear, possibly rarely subareolate; apothecia small to scarcely middle-sized, 0.5 to 1 mm. in diameter, adnate, frequently clustered and irregular, the disk very black, at first flat but becoming convex, the exciple soon disappearing and leaving the frequently shining disk without margin; hypothecium pale (or in ours becoming brownish or brown); hymenium pale below and usually brownish above; paraphyses simple or sometimes branched, frequently more or less coherent, usually enlarged and darker toward the apex; asci clavate; spores oblong-ellipsoid, 7 to 12 μ long and 3 to 4.5 μ wide.

Lecidea elabens Fr. from Warroad, determined by Dr. T. Hedlund, scarcely differs.



MEGALOSPORA SANGUINARIA (L.) KOERB.

Collected at Gunflint, along Snowbank Lake and in the Misquah Hills. On old wood.

Found in New England, Iowa, Colorado, and Alaska. Known also in Europe.

EXPLANATION OF PLATE 4.—See page 67.

MEGALOSPORA Meyer, Nov. Act. Acad. Caes. Leop. Car. Suppl. 19¹: 228. 1843.

The thallus is crustose and variously roughened and verrucose. There is no distinct cortical layer, nor were the algal and medullary layers very distinctly differentiated in most of the material examined. The algæ are modified forms of *Cystococcus*, the cells varying considerably in size and form. Hyphal rhizoids serve for attaching organs, but are neither numerous nor conspicuous in the sections. The thallus is further described under our single species of the genus.

The apothecia are middle-sized or large, and are adnate. The exciple is proper and is evanescent, the disk commonly more or less convex. The hymenium and the hypothecium are sufficiently characterized in the description of the species. The spores are simple, hyaline, very large, one in each ascus.

Tuckerman included our single species in the genus *Heterothecium*, which includes also species having compound spores and others having compound-muriform and brown spores. That such a genus should not stand is certain enough. The present genus is closely related to *Lecidea*, from which it differs in the large and solitary spores and also in the commonly present red coloration of the hypothecium or adjoining portions of the apothecium. Perhaps the 2-celled members of the genus *Heterothecium* of Tuckerman's Synopsis are as closely related to the present genus as are the *Lecideas*.

The single American species and a subspecies occur in the northern portion of the State. On trees and dead wood.

Type species *Megalospora sulphurata* Meyer, loc. cit.

1. *Megalospora sanguinaria* (L.) Koerb. Syst. Lich. 257. 1855. PLATE 7.

Lichen sanguinarius L. Sp. Pl. 1140. 1753.

Thallus crustose, consisting of granules, these commonly becoming flattened and running together into a verrucose and more or less chinky and polished crust, sea-green, varying toward ashy, commonly widely and irregularly spread over the substratum as a continuous crust of moderate thickness; apothecia middle-sized or larger, 1 to 3 mm. in diameter, adnate, sometimes clustered and becoming irregular, the disk black and more or less shining, commonly convex, the exciple pale or rarely darkening or reddish, soon disappearing and seldom seen except in very young apothecia; hypothecium pale above and reddish below and resting upon a blood-red layer (hypothecium said to be sometimes black, while some authors consider the whole structure pale and the red layer wholly subhypothecial and others yet speak of the hypothecium as red); hymenium pale or reddish brown below and only slightly darker above; paraphyses simple or rarely branched, somewhat thickened and darker toward the apex; asci clavate or more or less irregular; spores oblong-ellipsoid, hyaline or pale, 56 to 90 μ long and 22 to 46 μ wide.

Thus far collected only in the northeastern portion of the State. On trees and old wood and rarely on rocks.

Elsewhere in North America, in New England, New York, California, and Oregon, and widely distributed in British America. Known also in Europe and Asia.

Heterothecium sanguinarium of the preliminary reports.

EXPLANATION OF PLATE 7.—Plants on wood, showing the crustose thallus and the apothecia. Enlarged to about 1½ diameters.

1a. *Megalospora sanguinaria affinis* (Schaer.) Fink.

Lecidea affinis Schaer. Enum. Lich. Eur. 132. 1850.

Apothecia without the red coloration below the hymenium and in the exciple; whole plant smaller in ours.

Collected at Rose Lake along the northern boundary. On old wood.

Referred to by Tuckerman, but without giving localities. Known also in Europe and Asia.

Heterothecium sanguinarium affine of the preliminary reports.

BIATORINA Mass. Ric. Lich. 134. f. 262-271. 1852.

The thallus is crustose and commonly granulose and often passes into verrucose or rugose-verrucose conditions, but is seldom or never in any degree areolate. It is thinner as a whole than that of Lecideas and is more commonly rudimentary or evanescent. The thallus development is on the whole better than in Biatorella, but there is no suggestion of a cellular cortex in any of the species examined. Neither are there any internal tissue layers. As in the closely related genera, the rudimentary structure lies mainly above the substratum and is attached by hyphal rhizoids. The algal cells, in ours at least, are the common Cystococcus, though others insist that *Chroolepus* is the common form.

The apothecia are usually small or minute and are commonly adnate. The exciple is as in section Biatora of the Lecideas, and frequently disappears, leaving the apothecium without margin. The disk is flat or more or less convex. The hypothecium and the hymenium vary in color from pale to brownish or brown, though bluish or pale violet shades are to be looked for in the upper portion of some hymenia. The spores are 2-celled, hyaline, and variously ovoid, oblong, ellipsoid, or even somewhat fusiform.

The genus is doubtless derived phylogenetically from some form or forms of Lecidea, and this view is strengthened by the fact that among the Lecideas, and probably among Biatorinas also, there are species having both simple and 2-celled spores. On the other hand, the relationship between the present genus and Bilimbia is perhaps as close, and it appears reasonable to suppose that the Bilimbias were derived from certain Biatorinas, by a second cell division of the spores, or the latter perhaps more probably from the former by spore degeneration, the same being true for Lecideas and Biatorinas. The exciple is a rather weaker structure even than that of the section Biatora, and this condition and the presence of a septum in the spores removes the members of the present genus further from our common Eulecideas than from members of the above section. In some respects the species of the genus *Gyalecta* as viewed by Tuckerman seem quite closely related to the present genus, or to Bilimbia or Bacidia. It may well be questioned, in view of the transitional forms, whether Lecideas and Biatorinas should be separated.

Thus far only five representatives of Biatorina have been met with in Minnesota. Four occur on wood and the fifth is parasitic on another lichen.

Type species *Biatorina griffithii* (Ach.) Mass. loc. cit.

KEY TO THE SPECIES.

- Parasitic on *Peltigera*, with very inconspicuous thallus and apothecia..... 3. *B. heerii*.
- Not parasitic on other lichens.
- Thallus remaining ashy.
- Spores normal; thallus inconspicuous and apothecia small or minute..... 1. *B. tricolor*.
- Spores sometimes simple; plants otherwise as above... 1a. *B. tricolor atlantica*.
- Thallus not often finally ashy.
- Thallus usually becoming greenish or brownish; apothecia small or minute, brown or blackish..... 2. *B. atropurpurea*.
- Thallus olivaceous-greenish or blackish; apothecia small or minute, brown or becoming blackish..... 4. *B. prasina*.

1. *Biatorina tricolor* (With.) Fink.

Lichen tricolor With. Arr. Brit. Pl. ed. 3: 20. 1796.

Thallus composed of very minute granules, these commonly running together to form a thin, more or less chinky or obscurely rugose-verrucose, ashy crust, continuously widespread over the substratum or more or less scattered; apothecia small or minute, in ours 0.15 to 0.25 mm. in diameter, adnate, the disk flat or slightly convex, flesh-colored passing through shades of brown to blackish, the paler exciple sometimes disappearing (disk said by Tuckerman to be pruinose); hypothecium pale or yellowish; hymenium pale throughout, or sometimes brownish above; paraphyses commonly simple, the apex frequently somewhat thickened and brownish; asci clavate or cylindrico-clavate; spores oblong, varying toward ellipsoid or fusiform, and sometimes more or less curved, 9 to 15 μ long and 3 to 4.5 μ wide.

Generally distributed over the northern portion of the State. On trees, especially on poplars. Both this and the next two are easily confused with *Arthonia patellulata*, which most commonly grows on the same substratum.

Widely distributed in the northern United States and northward to arctic America, also found in Florida and southern California. Known also in Europe and Africa.

Biatora mixta is the synonym used in the preliminary reports.

1a. *Biatorina tricolor atlantica* (Tuck.) Fink.

Biatora mixta atlantica Tuck. Syn. N. A. Lich. 2: 30. 1888.

Thallus as in the above, as is also the whole external appearance; internally differing in that the spores are frequently, and in some specimens commonly, simple. The plant is little known, and it may possibly represent immature conditions. If not, it is an interesting connecting form between the present genus and *Lecidea*.

Collected at Battle Lake. On poplars.

Elsewhere noted only in New England.

Biatora mixta atlantica is the synonym used in the preliminary reports.

2. *Biatorina atropurpurea* (Schaer.) Mass. Ric. Lich. 135. f. 265. 1852.

Lecidea sphaeroides atropurpurea Schaer. Enum. Lich. Eur. 140. 1850.

Thallus composed of very minute granules, these usually running together to form a somewhat chinky or leprose, widespread, thin, and rarely more or less soresiate crust, ashy in color, varying toward greenish or brownish and sometimes disappearing; apothecia small or minute, 0.18 to 0.35 mm. in diameter, adnate or slightly immersed in the thin thallus, the disk flat to strongly convex, the exciple disappearing early in ours, and the oftentimes immersed apothecia having thus a falsely lecanoroid appearance, brown and varying toward blackish; hypothecium pale or pale brownish; hymenium pale or pale brownish below and darker above; paraphyses commonly simple, usually somewhat thickened and brownish toward the apex, asci cylindrico-clavate; spores ellipsoid, 10 to 16 μ long and 3.5 to 6 μ wide.

Spores somewhat narrower, exciple more evanescent, and apothecia smaller than in the plant as described by Tuckerman and Th. Fries, and our plant on the whole perhaps intermediate between theirs and the last above.

Throughout the northern portion of the State. On trees, especially on poplars.

Reported also from New England, Illinois, Florida, California, and points northward through eastern British America to Newfoundland. Well known also in Europe, but further distribution scarcely to be ascertained in the present state of synonymy.

Biatora atropurpurea of the preliminary reports.

3. *Biatorina heerii* (Hepp) Fink.

Biatora heerii Hepp, Spor. Flecht. Eur. pl. 16. f. 135. 1853.

Thallus composed of very minute rounded and frequently heaped granules, sometimes visible with a lens, often seen only in sections, rarely disappearing entirely; apothecia minute, 0.1 to 0.2 mm. in diameter, sessile or adnate, flesh-colored and black-

ening, the disk flat or slightly convex, the exciple of about the same color or becoming darker, usually persistent; hypothecium colorless to brownish; hymenium of same colors and frequently darker below; paraphyses commonly simple, sometimes slightly thickened and brownish toward the apex; asci clavate; spores ovoid to ellipsoid, 7 to 12 μ long and 3 to 5.5 μ wide.

A single collection was made at Tower. On *Peltigera canina*.

Known elsewhere in North America in Massachusetts, Illinois, and Newfoundland. Found also in Europe, Asia, and Africa.

Biatora heerii of the preliminary reports.

4. *Biatorina prasina* (Fr.) Fink.

Micarea prasina Fr. Syst. Orb. Veg. 257. 1825.

Thallus composed of very minute granules, these closely clustered or even sometimes heaped more or less and forming a widely spread, frequently subleprose, usually dark olivaceous-green or blackish crust; apothecia small or minute, 0.2 to 0.5 mm. in diameter, commonly convex or globular and the exciple disappearing early, brown or in ours more commonly black or blackish, the whole structure in ours frequently irregular or depressed; hypothecium pale or brownish; hymenium pale below and commonly darker above; paraphyses commonly simple, somewhat gelatinized and indistinct; asci clavate; spores commonly 2-celled, but in ours more commonly simple, oblong-ovoid, 8 to 12 μ long and 3.5 to 5 μ wide.

Dr. A. Zahlbruckner has placed ours under subspecies *byssacea* (Zwackh) Th. Fr., based on the darker color of the apothecia, the darker apices of the paraphyses, and the frequently simple spores.

A single collection was made at Bemidji. On old wood.

Reported elsewhere in North America from Massachusetts, Illinois, Georgia, Washington, and California. Known also in Europe.

Biatora prasina of the preliminary reports.

BILIMBIA De Not. Giorn. Bot. Ital. 2¹:190. 1846.

The thallus is crustose and commonly composed of minute granules, which run together into a smooth or variously leprose or verrucose crust, never distinctly areolate, in any of our species at least, though squamose in some North American species. Thallus on the whole somewhat less conspicuous and also more rudimentary internally than in *Lecidea*, though seldom disappearing entirely. In position relative to the substratum and mode of attachment to it similar to *Lecidea*. The algal symbiont is a modified form of *Cystococcus*, in which the cells are perhaps on the whole smaller than usual and united in larger numbers.

The apothecia, like those of *Biatorella* and *Biatorina*, are small or minute, none of our members of this or of those genera reaching the middle-sized conditions so frequent among *Lecideas* and *Bacidias*. In form of apothecia, nature and constancy of exciple, color of hypothecium and hymenium, and appearance of paraphyses and asci, the present genus is essentially like the four closely related genera just mentioned. However, the spores differ from those of *Biatorinas* in that they are from 4 to 9-celled, and from those of *Bacidias* in that they are distinctly wider and on the whole shorter and fusiform or finger-shaped instead of being needle-shaped.

The *Bilimbias* are evidently most closely related to the *Bacidias*, and indeed it may well be doubted whether the species should be separated into two genera. The species, however, form two groups, whether genera or not, and though the student will find some trouble at first in deciding with which a species having a given spore form should be placed, the difficulty will pass away with a little observation of the various forms. Transitional spore forms scarcely exist in our species, though some real difficulty due to such is encountered in the study of certain forms from other regions. The plant of the preliminary reports placed in the genus *Lecidea*, under the name *Lecidea acclinis* Flot., appears to present stronger affinities with the present genus and has been transferred.

Though only four *Bilimbias* have thus far been found in the State, some one or more of them may be looked for on almost any common kind of lichen-bearing substratum.

Type species *Bilimbia hexamera* De Not. loc. cit. (*Bilimbia hypnophila* (Ach.) Th. Fr.)

KEY TO THE SPECIES.

Spores 4-celled; apothecia small, usually adnate, strongly convex, flesh-colored to reddish brown..... 1. *B. sphaeroides*.

Spores 4 to 8-celled.

Apothecia always black, small or minute, usually flat..... 4. *B. acclinis*.

Apothecia becoming black.

Apothecia at first light brown; hypothecium pale brownish to brown..... 2. *B. hypnophila*.

Apothecia at first flesh-colored; hypothecium pale to pale brownish..... 3. *B. naegeli*.

1. *Bilimbia sphaeroides* (Dicks.) Koerb. Syst. Lich. 213. 1855.

Lichen sphaeroides Dicks. Pl. Crypt. Brit. 1: 9. pl. 2. f. 3. 1785.

Thallus composed of minute, closely aggregated or even heaped, greenish, sea-green, or ashy granules, these forming a usually continuous, thin, and widely spread crust, this sometimes becoming leprose or only subgranulose, rarely also becoming thicker, and the granules raised and subcoralloid, or the thin crust almost entirely disappearing; apothecia small, 0.25 to 0.95 mm. in diameter, adnate or rarely sessile, becoming strongly convex and even subglobose, scattered or clustered, flesh-colored to reddish brown, the thin exciple disappearing early; hypothecium pale to light brown; hymenium pale to pale brownish; paraphyses simple or branched toward the apex, this is commonly somewhat enlarged and brownish; asci long-clavate; spores ellipsoid to fusiform, 4-celled, 13 to 23 μ long and 4 to 7 μ wide.

Generally distributed over the northern portion of the State, but rather rare. On mossy tree bases and more rarely on old wood.

Reported from Florida, but otherwise confined in the United States to the White Mountains (New Hampshire) and the Rocky Mountains. Common throughout British America. Known also in Europe and Asia.

Biatora sphaeroides of the preliminary reports.

2. *Bilimbia hypnophila* (Ach.) Th. Fr. Nov. Act. Reg. Soc. Sci. Ups. III. 3: 283. 1861.

Lecidea hypnophila Ach. Lich. Univ. 199. 1810.

Thallus composed of minute, crowded, and sometimes more or less confluent granules, these forming a crust scarcely differing in appearance from that of the last, tending to disappear when on wood; apothecia smaller than in the last, 0.2 to 0.75 mm. in diameter, becoming strongly convex and the exciple disappearing, light brown to black, adnate or sessile, scattered or clustered; hypothecium pale brownish to dark brown; hymenium pale or pale brownish below and darker above; paraphyses simple or rather rarely branched, commonly enlarged and brownish toward the apex; asci clavate or long-clavate; spores ellipsoid to fusiform, 4 to 8-celled, 16 to 32 μ long and 4 to 7.5 μ wide.

Though very close to the last, the two, commonly united by European lichenists, seem distinct as exhibited in our region. Differences in spore measurements, as also in size and internal and external coloration of apothecia, are obvious, *Bilimbia sphaeroides* reminding one externally of *Biatora vernalis*.

Generally distributed over the State. On mossy tree bases, or more rarely on earth or old wood.

Generally distributed over North America, being quite as common northward as the last and also well represented southward. Present in Europe, but commonly included with the last above.

Biatora hypnophila of the preliminary reports.

3. Bilimbia naegelii (Hepp) Zwackh, Flora **45**: 505. 1862.

Biatora naegelii Hepp, Spor. Flecht. Eur. pl. 4. f. 1, 19. 1853.

Thallus composed of granules somewhat coarser than in the last two and usually somewhat flattened to form a chinky or more or less irregularly roughened crust, this confined to suborbicular patches, 5 to 15 mm. or more in diameter, or widely scattered as a usually thin layer, commonly sea-green to ashy, but ours quite uniformly darker and even tending toward olivaceous; apothecia small, 0.2 to 0.9 mm. in diameter, scattered or more commonly numerous and more or less clustered, adnate or rarely sessile, flat and with thin exciple, or more commonly convex and immarginate, dark brown to black, said to be at first flesh-colored; hypothecium pale or pale brownish; hymenium pale throughout or brownish above; paraphyses simple or rarely branched, commonly thickened and darker toward the apex; asci clavate; spores fusiform-ellipsoid, commonly 4-celled, 18 to 25 μ long and 3.5 to 5.5 μ wide, said to be sometimes 6 or 8-celled.

Collected at Beaver Bay and at Granite Falls. The plant is usually difficult to detect, being easily passed over for some other species, and is doubtless quite generally distributed over the State. On trees.

Known elsewhere in North America in Massachusetts and Florida. Common in Europe.

Biatora naegelii of the preliminary reports.

4. Bilimbia acclinis (Koerb.) Fink.

Arthrosporum accline Koerb. Syst. Lich. 270. 1855.

Thallus composed of minute granules, these commonly compacted into a rugose-verrucose or subleprose crust, in the few specimens seen covering small irregular or suborbicular patches of substratum, 6 to 14 mm. in diameter, sea-green to ashy, frequently disappearing; apothecia small or minute, 0.5 to 0.75 mm. in diameter, said to reach 1 millimeter, adnate, flat and having a thin exciple or becoming convex and immarginate, black, commonly scattered; hypothecium pale brownish; hymenium pale below and somewhat darkened above; paraphyses slender and frequently branched, commonly thickened and dark-colored above; asci clavate or inflated-clavate; spores becoming 4-celled, somewhat curved and usually plainly constricted at the septa, sometimes more than 8 in each ascus, 9 to 18 μ long and 4 to 5 μ wide.

Collected at Gunflint, Battle Lake, and Thief River Falls. On trees. Another inconspicuous lichen, which doubtless occurs in other portions of the State. The species has been collected in northern Iowa and may be looked for in southern Minnesota.

Elsewhere in North America in Massachusetts, New Hampshire, and Nebraska. Known also in Europe.

Lecidea acclinis is the synonym under which the plant occurs in the preliminary reports.

BACIDIA De Not. Giorn. Bot. Ital. **2**: 189. 1846.

The thallus is crustose and granulose, showing chinky, verrucose, or even sub-areolate or subsquamulose conditions. The margins in some of the best developed North American species are more or less lobulate, and the whole macroscopic structure only slightly inferior to that of the Lecideas and better developed than in Bilimbia. The thallus is frequently somewhat obscure, but seldom or never entirely disappears. Microscopically it is quite as rudimentary as in the two genera named above, and the algal symbiont is also apparently Cystococcus. The position and attachment to the substratum is likewise quite the same as in the closely related genera of the group.

The apothecia are of about the same size as those of the Lecideas, reaching middle size, though small and minute forms are somewhat more common in the present

genus. They are most commonly adnate, though sessile or somewhat immersed conditions are not unknown. The exciple is strictly lecideoid and frequently disappears. The disk is most commonly convex and varies in color from flesh color through various shades of brown to black. The hypothecium and the hymenium are usually more or less brownish, and the former may become quite dark. However, both may be pale in color. The paraphyses are essentially like those of the closely related genera, being commonly more or less coherent and simple, though branched forms may be looked for in any of the species. The asci differ slightly in that they are usually long-clavate or cylindrico-clavate. The spores are of the long slender form called acicular and are from 4 to 16-celled. Possibly the cells may rarely exceed this number, but the septa are frequently difficult to distinguish. Curved or twisted spore forms are common, and one end of the spore is usually wider and more rounded than the other. The species are very variable and difficult to determine or to differentiate in descriptions.

The spore characters relate the present genus most intimately to *Bilimbia*, while *Lecidea*, with its simple spores, stands at the opposite end of the series of closely related forms, with *Biatorella*, *Biatorina*, and *Bilimbia* as intermediate forms. And the external resemblance is so close in all of these genera that one can not always be sure even of the genus until the spores are examined.

A dozen species have been found in the State. On trees, and more rarely on rocks, moss, or earth.

Type species *Bacidia rosella* (Ach.) De Not. loc. cit.

KEY TO THE SPECIES.

- Apothecia reddish brown to brown, never black..... 2. *B. rubella*.
 Apothecia always or finally black.
 Apothecia always black, minute, flat or finally convex.... 8. *B. akompsa*.
 Apothecia becoming black.
 Apothecia at first reddish.
 Apothecia not flexuous, small, sessile, black..... 1. *B. atrosanguinea*.
 Apothecia often flexuous.
 Plants on trees; thallus of rather coarse greenish or brownish granules..... 11. *B. chlorantha*.
 Plants usually on mosses; thallus a minute sea-green or whitish crust..... 9. *B. muscorum*.
 Apothecia at first lighter or darker brown.
 Apothecia at first pale brown.
 Apothecia small or minute; plants commonly on rocks.
 Spores hamate or spirally twisted..... 10. *B. umbrina*.
 Spores not hamate nor spirally twisted... 6. *B. inundata*.
 Apothecia middle-sized or larger; plants usually on trees.
 Apothecia often with pruinose exciple... 3. *B. fuscobella*.
 Apothecia having the whole disk pruinose..... 3a. *B. fuscobella suffusa*.
 Apothecia at first dark brown or darker.
 Apothecia frequently flexuous.
 Apothecia middle-sized, sessile or adnate, flattish, dark brown or black.... 4. *B. schweinitzii*.
 Apothecia small or minute, commonly flat and adnate, black or blackish.... 7. *B. incompta*.

Apothecia never flexuous.

- Apothecia soon convex, small, dark brown to black. 5. *B. endoleuca*.
 Apothecia remaining flat or becoming slightly convex, small or minute, dark brown to black. 12. *B. bacillifera*.

1. *Bacidia atrosanguinea* (Schaer.) Anzi, Cat. Lich. Sondr. 70. 1860.

Lecidea anomala atrosanguinea Schaer. Lich. Helv. Spic. 4: 170. 1833.

Thallus composed of minute granules, these usually contiguous and united into a roughened, chinky, or subleprose, widely spread, usually thin, ashy to sea-green crust, rarely disappearing; apothecia rather small, 0.2 to 0.85 mm. in diameter, sessile, flat with evident persistent exciple or rarely concave, or slightly convex, in ours black, but said to be sometimes dark reddish; hypothecium reddish-brown; hymenium pale below and pale brownish above; paraphyses simple or rarely branched, sometimes enlarged and darker toward the apex; asci cylindrico-clavate; spores several-celled, 30 to 50 μ long and 3 to 4.5 μ wide.

A single collection was made at Warroad. On trees.

Not known elsewhere in America. Well known in Europe.

Biatora atrosanguinea of the preliminary reports.

2. *Bacidia rubella* (Hoffm.) Mass. Ric. Lich. 118. f. 231. 1852.

PLATE 5, B.

Verrucaria rubella Hoffm. Deutsch. Fl. 2: 174. 1795.

Thallus composed of minute scattered or crowned granules, frequently becoming compacted into a subleprose or more or less verrucose or chinky, sea-green, ashy, or rarely yellowish crust, irregularly and often widely spread over the substratum as a moderately thick or thinner layer, this sometimes becoming scattered and inconspicuous or disappearing entirely; apothecia small to middle-sized, 0.5 to 1.35 mm. in diameter, sessile or adnate, reddish yellow or reddish brown, flat with a rather thick and lighter-colored exciple, or becoming convex and the margin disappearing; hypothecium yellowish to brown; hymenium pale yellowish; paraphyses simple or rarely branched, sometimes slightly thickened and brownish toward the apex; asci long-clavate; spores several-celled (possibly sometimes as many as 16-celled), 45 to 65 μ long and 3 to 4 μ wide.

A form with pruinose margin is known as subspecies *porriginosa* (Turn.) Arn. Another with naked exciple is subspecies *luteola* (Schrad.) Th. Fr. Ours is usually the latter. Th. Fries notes spores 100 μ long in European forms.

Generally distributed over the State. On trees.

The species is generally diffused in North America. The synonymy is somewhat uncertain, but the plant seems to occur in all of the grand divisions.

Biatora rubella of the preliminary reports.

EXPLANATION OF PLATE 5.—See page 71.

3. *Bacidia fuscorubella* (Hoffm.) Arn. Flora 54: 55. 1871.

Verrucaria fuscorubella Hoffm. Deutsch. Fl. 2: 175. 1795.

Thallus composed of rather coarser and less frequently scattered granules than the last, these forming a more conspicuous and commonly more widely spread, thicker, more rugose or chinky crust, more commonly continuous and rarely becoming scattered or tending to disappear, in color similar to the last; apothecia small to middle-sized, 0.6 to 1.5 mm. in diameter, sessile or adnate, flat, with an elevated and often transversely striate and pruinose exciple, less commonly becoming somewhat convex, the margin then disappearing, pale brown to darker and finally black; hypothecium yellow to brown; hymenium yellowish; paraphyses simple or rather rarely branched, commonly thickened and brownish toward the apex; asci long-clavate; spores about 7 to 14-celled, 40 to 75 μ long and 3 to 5 μ wide.

There are two subspecies of this plant, also, recognized in Europe, but scarcely to be distinguished in our material. The present species is on the whole better developed than the last and distinct from it, but the so-called subspecies *porriginosa* of the last is in some respects intermediate, as are other forms met in collecting.

Distribution in the State as general as that of the closely related *Bacidia rubella*. On trees and rarely on rocks.

North American distribution also as in the last. Well known in Europe and Asia and doubtless more widely distributed.

Biatora fuscorubella of the preliminary reports.

3a. *Bacidia fuscorubella suffusa* (Fr.) Fink.

Biatora suffusa Fr. Syst. Orb. Veg. 285. 1825.

Thallus quite similar to that of the last; apothecia on the whole larger, 1.75 to 2 mm. in diameter, with rather stouter exciple and the whole surface usually suffused with a white powder; internally like the last, except that the spores are slightly narrower, 2.5 to 3.5 μ wide.

No. 102 of Lichenes Boreali-Americani, collected at Fayette, Iowa, is the best representative generally distributed, though some of this is hardly the subspecies.

Reported from Mankato, Granite Falls, and Red Lake, but some of the material is doubtless not the subspecies. On trees.

Tuckerman credited the plant with probably the same North American range as the species, but considered the subspecies a distinct species. Known also in Europe, but further distribution can not be given in the present state of synonymy.

Biatora suffusa of the preliminary survey.

4. *Bacidia schweinitzii* (Tuck.) Fink.

Biatora schweinitzii Tuck. in Darl. Fl. Cestr. ed. 3. 447. 1853.

Thallus composed of rounded and often crowded or even heaped granules, these frequently compacted into a continuous or scattered and commonly widely spread, chinky or verrucose, sea-green to olivaceous crust, this thin and somewhat inconspicuous or sometimes thicker and better developed than in any of the preceding, sometimes becoming ash-colored; apothecia middle-sized or larger, 0.6 to 1.75 mm. in diameter, sessile or adnate, flat or slightly convex, commonly dark brown or black and becoming flexuous, the exciple rather thick and lighter-colored or of same color, frequently becoming quite flexuous; hypothecium yellowish to dark brown; hymenium pale to yellowish, or sometimes bluish or pale violet above; paraphyses simple or rarely branched, commonly thickened and darker toward the apex; asci long-clavate; spores about 7 to 15-celled, 40 to 70 μ long and 2.5 to 3.5 μ wide.

Collected in the Misquah Hills, on Oak Island, and at Harding. The plants from the second locality were unusually well developed, with conspicuous thallus and large apothecia and spores. On trees, especially cedars in swamps.

A strictly North American plant, distributed widely east of the Mississippi River, from the southern United States northward into British America.

5. *Bacidia endoleuca* (Nyl.) Kickx, Fl. Crypt. Fland. 1: 261. 1867.

Biatora luteola endoleuca Nyl. Nya Bot. Notis. 98. 1853.

Thallus composed of minute granules, these compacted into a thin, smoothish, chinky or finally chinky-verrucose, commonly widely spread, sea-green, ashy or rarely darker crust, rarely disappearing; apothecia small, 0.5 to 0.75 mm. in diameter, sessile or adnate, at first slightly concave with a somewhat elevated and thick exciple, but soon convex and immarginate, the disk and exciple blackish brown to black; hypothecium pale to reddish brown or brown; hymenium pale below and brownish or brownish-violet above; paraphyses simple or rarely branched, commonly thickened and darker above; asci long-clavate; spores most commonly about 8-celled (4 to 16, according to Fries), 30 to 65 μ long and 2.5 to 4.5 μ wide.

Collected at four or five localities in the northwestern portion of the State. On trees.

The plant is reported from widely separate portions of the United States and British America and may be looked for anywhere in North America, except perhaps in arctic regions. Known in all of the grand divisions except possibly Asia.

Biatora atrogrisea is the synonym of the preliminary reports.

6. *Bacidia inundata* (Fr.) Koerb. Syst. Lich. 187. 1855.

Biatora inundata Fr. Vet. Akad. Handl. 1822: 270. 1822.

Thallus composed of minute granules, these commonly compacted into a thin or rarely thicker, chinky or subareolate, commonly widely spread, continuous or more or less broken, sea-green, ashy, or darkening crust; apothecia small or minute, 0.3 to 0.7 mm. in diameter, adnate or rarely somewhat immersed, the disk at first flat and bordered by an exciple, but soon becoming convex and the exciple disappearing, pale brownish, brown, or finally black, the exciple at first lighter than the disk, sometimes more or less clustered; hypothecium pale to brown; hymenium pale or brownish; paraphyses simple or rarely branched toward the apex, there also usually enlarged and brownish, somewhat more coherent than in most species; asci clavate or long-clavate; spores 4 to 8-celled, 20 to 40 μ long and 1.5 to 2.5 μ wide.

Generally distributed in the State. On various rocks in moist places, and rarely on wood.

Throughout the United States east of the Rocky Mountains and northward to Newfoundland. Well known in Europe.

Biatora inundata of the preliminary reports.

7. *Bacidia incompta* (Borr.) Anzi, Cat. Lich. Sondr. 70. 1860.

Lecidea incompta Borr. in Sowerby, Engl. Bot. Suppl. 2: pl. 2699. 1834.

Thallus composed of very minute granules, these forming a continuous or more or less broken, widely spread, sometimes thicker and rugose or possibly even subareolate, or again thin and smooth or more or less mealy, lighter or darker sea-green crust, sometimes becoming obscure or disappearing; apothecia small or minute, 0.35 to 0.75 mm. in diameter, adnate or perhaps rarely sessile, flat, with a thin and frequently flexuous margin, but becoming convex, black or brownish black; hypothecium brownish to reddish brown (rarely pale); hymenium pale below and brownish above; paraphyses simple or rarely branched toward the apex, there frequently thickened and darker; asci long-clavate; spores in ours 4 to 12-celled, 18 to 35 μ long and 1.5 to 3 μ wide.

Collected on the northern boundary at Rose Lake and at Gunflint. On trees.

Known elsewhere in North America from New England and Illinois. Common in Europe and also reported from the Sandwich Islands.

Biatora incompta of the preliminary reports.

8. *Bacidia akompsa* (Tuck.) Fink.

Biatora akompsa Tuck. Syn. N. A. Lich. 2: 47. 1888.

Thallus composed of minute granules, these running together into a scurfy or more compact and chinky, smooth or rugose-verrucose, commonly widely spread, ash-colored crust; apothecia minute, 0.2 to 0.5 mm. in diameter, sessile or adnate, flat, with an uneven, thin margin, or later convex, black; hypothecium pale or brownish; hymenium pale or pale brownish below and the same or violet-tinged above; paraphyses simple or rarely branched toward the apex, there commonly enlarged and darker; asci cylindrico-clavate; spores scarcely more than 4-celled in ours, 19 to 24 μ long and 1.5 to 2.5 μ wide.

Collected at Battle Lake, Warroad, and Emo, all in the northwestern portion of the State. On trees.

A North American lichen, known elsewhere on the Pacific coast in California and on Vancouver Island.

Biatora akompsa of the preliminary reports.

9. *Bacidia muscorum* (Hoffm.) Fink.

Verrucaria muscorum Hoffm. Deutsch. Fl. **2**: 191. 1795.

Thallus composed of minute granules commonly run together into a widely spread rugose-verrucose, usually well developed, sea-green or whitish crust; apothecia small to middle-sized, 0.4 to 1.2 mm. in diameter, sessile or adnate, flat, with a thin and frequently flexuous margin, or perhaps more commonly becoming convex and immarginate, frequently conglomerately clustered, black or rarely reddish brown; hypothecium yellowish to dark brown; hymenium pale yellowish, or violet-tinged above; paraphyses simple or rarely branched, frequently thickened and darker toward the apex; asci long-clavate; spores about 6 to 10-celled, 25 to 45 μ long and 2 to 3.5 μ wide.

Generally distributed over the State. On earth, over mosses, and rarely on bark.

Also in New England, New York, Illinois, Iowa, and Nebraska and northward to arctic America. Known likewise in Europe and Asia.

Biatora muscorum of the preliminary reports.

10. *Bacidia umbrina* (Ach.) Branth & Rostr. Bot. Tidssk. **3: 235. 1869.**

Lecidea umbrina Ach. Lich. Univ. 183. 1810.

Thallus composed of minute granules, these commonly compacted into a thickish and continuous, or scattered and thinner, subleprose, chinky or subareolate crust; sea-green varying to ashy or even blackish, widely spread, the granules, when apparent, usually flattened, the whole thallus sometimes tending to disappear; apothecia minute, 0.25 to 0.6 mm. in diameter, adnate or somewhat immersed, at first flat, with a commonly paler margin, but becoming convex and immarginate, light brown to black; hypothecium pale brownish to brown; hymenium pale below and darker above; paraphyses simple or rarely branched, commonly enlarged and darker toward the apex; asci long-clavate or inflated-clavate; spores hamate or more or less spirally twisted, about 4 to 8-celled, 18 to 30 μ long and 2 to 3 μ wide.

Collected near Minneapolis. On calcareous rocks. Also a larger and doubtful form was collected on cedars in a swamp near Warroad. Doubtless occurs on rocks in other portions of the State, but very difficult to distinguish macroscopically from the more common *Bacidia inundata*.

Elsewhere in North America in New England, New Jersey, Virginia, North Carolina, Illinois, Iowa, Nebraska, and Labrador or Newfoundland. Known also in Europe and Asia.

Biatora umbrina of the preliminary reports.

11. *Bacidia chlorantha* (Tuck.) Fink.

Biatora chlorantha Tuck. Syn. Lich. N. E. 60. 1848.

Thallus composed of rather coarse and scattered granules, becoming flattened, and when more compacted forming a bright green or paler or even brownish, frequently chinky crust; apothecia small to middle-sized, 0.4 to 1.5 mm. in diameter, sessile, flat or slightly convex, dark reddish brown or more commonly black, the exciple thick, lighter-colored, often becoming flexuous; hypothecium pale or pale brownish; hymenium pale throughout or slightly darkened above; paraphyses commonly simple, sometimes slightly thickened and darker toward the apex; asci clavate or inflated-clavate; spores several-celled, 20 to 35 μ long and 2 to 3 μ wide, numerous (30 to 50) in each ascus.

A single collection was made at Beaudette. On balsams in a swamp.

A North American lichen known elsewhere in New England, New York, Ohio, Illinois, and Ontario.

Biatora chlorantha of the preliminary reports.

12. *Bacidia bacillifera* (Nyl.) Fink.

Lecidea bacillifera Nyl. Not. Sällsk. Faun. Flor. Fenn. **5**: 82. 1861.

Thallus composed of minute granules forming a scattered or more or less continuous crust, this ashy to sea-green, frequently disappearing; apothecia small or minute,

0.3 to 0.8 mm. in diameter, sessile, black or brownish black, flat or slightly convex, the exciple of the same color and often disappearing; hypothecium colorless or slightly brownish (in ours dark brown); hymenium pale; paraphyses commonly simple with apices sometimes thickened and darker-colored; asci cylindrico-clavate; spores 4 to 8-celled, acicular or oblong-cylindrical, usually straight, 18 to 32 μ long and 2.5 to 4 μ wide.

In ours the apothecia are often clustered and usually strongly convex, the exciple commonly absent.

Collected at Tofte and not previously reported from Minnesota. On poplar bark.

Found elsewhere on the island of Cuba.

BUELLIA De Not. Giorn. Bot. Ital. 2¹: 195. 1846.

The thallus is crustose and variously granulose, verrucose, and areolate, rather more inclined to areolate conditions than are the similar thalli of Lecideas and seldom showing typically granulose conditions. Though the thallus is on the whole rather more conspicuous than in the genus just named, its minute anatomy commonly reveals the same rudimentary condition, the cellular cortex being absent or barely suggested in the sections. Neither can algal and medullary layers be distinguished. The thallus lies mainly above the substratum, to which it is attached by hyphal rhizoids. It is seldom of any considerable thickness, yet it is by no means so frequently evanescent as is the rather more rudimentary thallus of the Lecideas and some other closely related genera. The algal symbiont is a Cystococcus-like plant.

The apothecia are small or more rarely middle-sized, are circular or irregular in outline, and in position relative to the thallus vary from sessile to immersed conditions. The disk is commonly black and is flat or convex. The proper exciple is also commonly black macroscopically, but more usually dark brown in section, as is also the hypothecium. The exciple is very similar to that of the Lecideas, and species of the two genera appear so much alike externally that their separation in the field can be accomplished only after long acquaintance. The hymenium is commonly pale or pale brownish. The spores, as the genus is here limited, are typically brown and 2-celled (4-celled in a few forms admitted and indicated in the descriptions), and vary in form from oblong to ellipsoid. Decolorate conditions of spores are occasionally met with in the genus.

As to structure of the thallus and apothecia (exclusive of the spores) the genus seems nearest to Lecidea and Rhizocarpon, while the spore characters seem to indicate a relationship with such genera as Rinodina and Physcia. And while the relationship with Lecidea is on the whole much closer than that with Rinodina, the spores always serve to distinguish between the present genus and the Lecideas, while in spite of the usual presence of a well-defined thalloid exciple in Rinodina, it is by no means always easy to distinguish between Buellias and Rinodinas.

Some fourteen forms occur in the State. On trees, rocks, and old wood.

Type species *Buellia canescens* (Ach.) De Not. op. cit. 197.

KEY TO THE SPECIES.

Parasitic on other lichens, and no thallus discernible.

Exciple commonly disappearing; apothecia minute, black. 9. *B. parmeliarum*.

Exciple persistent or tardily disappearing.

Spores normal.

Spores 9 to 13 μ long and 3 to 6 μ wide..... 7. *B. saxatilis*.

Spores 10 to 18 μ long and 6 to 8 μ wide..... 8. *B. inquilina*.

Spores 4-celled.

Spores 10 to 16 μ long and 3 to 6 μ wide..... 10. *B. parasitica*.

Spores 21 to 28 μ long and 7 to 9 μ wide..... 11. *B. glaucomaria*.

Not parasitic on other lichens.

On rocks.

- Thallus sea-green or ashy, flat-areolate; spores 9 to 16 μ long and 4 to 7.5 μ wide..... 1. *B. spuria*.
 Thallus gray to brownish or reddish brown; spores 25 to 38 μ long and 11 to 17 μ wide..... 12. *B. badioatra*.

On trees or old wood.

Thallus usually sea-green or ashy.

Thallus commonly smooth, rarely areolate, thicker.

Spores normal; apothecia small to middle-sized..... 2. *B. parasema*.

Spores 3 or 4-celled; apothecia as above 2a. *B. parasema triphragmia*.

Thallus thin, scurfy or chinky.

Spores 8 in each ascus; apothecia minute and black..... 4. *B. myriocarpa*.

Spores 12 or more in each ascus; apothecia as above..... 4a. *B. myriocarpa polyspora*.

Thallus not sea-green.

Thallus whitish-ashy; spores 19 to 31 μ long and 7 to 11 μ wide..... 3. *B. dialyta*.

Thallus brownish-ashy.

Thallus verrucose and becoming areolate (rarely on rocks); spores 9 to 15 μ long and 4 to 7 μ wide..... 5. *B. turgescens*.

Thallus scurfy, granulate, or sorediate; spores 6 to 10 μ long and 2 to 4 μ wide.... 6. *B. schaereri*.

1. Buellia spuria (Schaer.) Arn. Flora **55**: 291. 1872.

Lecidea spuria Schaer. Lich. Helv. Spic. **3**: 127. 1827.

Thallus more or less roughened and areolate, the areoles small and flat or becoming more or less convex and commonly multiangular and black-edged, either scattered upon the conspicuous so-called hypothallus or crowded into a continuous crust, sea-green or more commonly ashy-gray; apothecia small, 0.4 to 0.8 mm. across, adnate or immersed, the disk black and flat or slightly convex, the exciple black and prominent or rarely disappearing; hypothecium dark brown; hymenium pale or slightly brownish, especially above; paraphyses simple or rarely branched, commonly enlarged and brownish toward the apex; asci clavate or inflated-clavate; spores brown, ellipsoid or oblong-ellipsoid, frequently somewhat constricted at the septum, 9 to 16 μ long and 4 to 7.5 μ wide.

Collected in several places in the southwestern portion of the State. On rocks other than calcareous.

The plant has a wide North American distribution and is also known in Europe and Africa.

2. Buellia parasema (Ach.) Koerb. Syst. Lich. 228. 1855.

Lichen parasemus Ach. Lich. Suec. 64. 1798.

Thallus commonly continuous and smooth, but often becoming thicker and roughened, chinky and finally areolate, but even showing occasionally granulate conditions, sea-green, ashy, or darkening, or even yellowish, bordered more or less by a black margin, the so-called hypothallus, rarely scattered upon the substratum as in the last; apothecia varying considerably in size, sessile or rarely adnate or even more or less immersed in specimens having thicker thalli, the disk usually flat and surrounded by a thin black exciple or becoming convex when the exciple (as rarely) disappears, the

exciple often more or less flexuous; hypothecium dark brown; hymenium pale, often with a brownish cast; paraphyses simple or rarely branched, commonly enlarged and brownish toward the apex; asci commonly clavate, but sometimes inflated-clavate or even tending toward cylindrical forms; spores brown, ellipsoid or oblong-ellipsoid, varying considerably in size, in ours 10 to 22 μ long and 5 to 10 μ wide, but such extreme sizes as 10 to 34 μ long and 5 to 12 μ wide credited to some of the European subspecies.

Found throughout the State and common in the well wooded portions. On trees and dead wood.

Generally distributed throughout North America. Known also in all the grand divisions, except possibly Asia.

2a. *Buellia parasema triphragmia* (Nyl.) Th. Fr. Nov. Act. Reg. Soc. Sci. Ups. III. 3: 327. 1861.

Lecidea triphragmia Nyl. Mém. Soc. Sci. Nat. Cherb. 5: 126. 1857.

Differs from the usual forms only in that the spores frequently show 3, 4, and even 6-celled conditions. Some of the largest spores reported in Europe belong to this subspecies.

Collected in the northeastern portion of the State at Gunflint and at Tofte. On trees. To be expected in any part of the State, but not common and easily overlooked in a macroscopic examination.

Rarely reported in North America, but the wide separation of the few stations indicates that the subspecies may be looked for wherever the species exists. Known also in all the grand divisions, its occurrence in Asia making it almost certain that the usual form of the species also occurs there.

3. *Buellia dialyta* (Nyl.) Tuck. Gen. Lich. 187. 1872.

Lecidea dialyta Nyl. Flora 52: 123. 1869.

Thallus thin or very thin, scurfy or granulose, or more or less compacted into a thin crust, white or ashy, irregularly spread over the substratum, said to rest upon a white so-called hypothallus; apothecia minute, 0.2 to 0.5 mm. across, sessile or adnate, the disk black and becoming slightly convex, the exciple thin and commonly disappearing; hypothecium dark brown; hymenium pale; paraphyses simple or rarely compound, frequently enlarged and brownish toward the apex; asci clavate; spores brown, fusiform-ellipsoid, 19 to 31 μ long and 7 to 11 μ wide.

Collected on pines at Two Harbors. Easily passed over for a condition of the last above.

Elsewhere in North America in New England, New York, and California. Not known in other grand divisions.

4. *Buellia myriocarpa* (Lam. & DC.) Mudd, Man. Brit. Lich. 217. 1861. FIGURE 11.

Patellaria myriocarpa Lam. & DC. Fl. Fr. ed. 3. 2: 346. 1805.

Thallus thin and scurfy or compacted into a smoothish or chinky crust, this irregularly spread over small areas of the substratum and frequently becoming roughened-verrucose, sea-green, ashy, or even white, often disappearing; apothecia minute, 0.2 to 0.6 mm. in diameter, adnate, often numerous, the disk black and flat, or becoming somewhat convex, the exciple also black, thin, and often disappearing; hypothecium dark brown; hymenium pale, or pale below and brownish above; paraphyses simple or branched, usually enlarged and brown toward the apex; asci clavate; spores brown, ellipsoid or oblong-ellipsoid, sometimes slightly constricted at the septum, 7 to 15 μ long and 4 to 7.5 μ wide.

Generally distributed over the State. On trees and old wood.

Widely distributed in North America. Also known in all the grand divisions except Africa.

4a. *Buellia myriocarpa polyspora* Willey in Tuck. Syn. N. A. Lich. 2: 97. 1888.

Differs in having 12 to 24 spores in each ascus.

Collected in widely separated localities and no doubt generally distributed in the State. Habitat as above.

Elsewhere in North America in Massachusetts, Illinois, Wisconsin, and Iowa. Not known in other grand divisions, unless it proves to be the same as *Buellia dives* Th. Fr.^a

Buellia myriocarpa punctiformis (Hoffm.) Mudd was reported from the northern portion of the State, but this is simply the condition of the species with thin and disappearing thallus, while subspecies *chloropolia* (Fr.) Th. Fr. is the form with thicker thallus.

5. *Buellia turgescens* (Nyl.) Tuck. Gen. Lich. 185. 1872.

Lecidea turgescens Nyl. Mém. Soc. Sci. Nat. Cherb. 5: 337. 1857.

Thallus verrucose and commonly areolate, or the swollen verrucæ crowded into a more or less plicate crust; brownish ashy or rarely with a reddish cast, irregularly scattered over the substratum, the thallus in some of the rock specimens showing some suggestion of a cellular cortex; apothecia minute, 0.2 to 0.7 mm. in diameter, adnate or more or less immersed, the disk black or dark brown, flat or slightly convex, the exciple also black and sometimes disappearing; hypothecium dark brown; hymenium pale or perhaps more commonly brownish, especially above; paraphyses rarely branched, commonly thickened and brown toward the apex; asci clavate; spores ellipsoid, brown, 9 to 15 μ long and 4 to 7 μ wide.

Generally distributed over the State. On dead wood and also on rocks.

The rock form was recorded in the preliminary reports as *Buellia pullata* Tuck.

Elsewhere in North America in New England. Known also in Australia.

6. *Buellia schaeferi* De Not. in Giorn. Bot. Ital. 2¹: 199. 1846.

Thallus thin and scurfy, becoming granulose or sorediate-powdery, brownish-ashy, often disappearing; apothecia minute or very minute, 0.15 to 0.45 mm. in diameter, adnate, the disk black and flat or becoming variously convex, plicate or papillate, the exciple thin, brownish black, often disappearing; hypothecium dark brown, or rarely much lighter or only slightly colored; hymenium pale, or pale below and brownish above; paraphyses commonly cohering closely, enlarged and brownish toward the apex; asci short-clavate or inflated-clavate; spores brown, ellipsoid or oblong-ellipsoid, 6 to 10 μ long and 2 to 4 μ wide.

Collected only at Rainy Lake City, but easily overlooked and doubtless occurring elsewhere in northern Minnesota. On pines.

Elsewhere in North America in New England, New Jersey, New York, Illinois, and Ontario. Known also in Europe and Africa.

7. *Buellia saxatilis* (Schaer.) Koerb. Syst. Lich. 228. 1855.

Calicium saxatile Schaer. Naturw. Anzeig. Schw. Ges. 5: 35. 1821.

Parasitic, and no thallus discernible except that of the host; apothecia minute, 0.2 to 0.4 mm. in diameter, sessile on the thallus of the host or at first somewhat immersed, the disk flat and black or rarely becoming convex, the exciple brownish black, commonly elevated, persistent, rather thick; hypothecium dark brown; hymenium pale

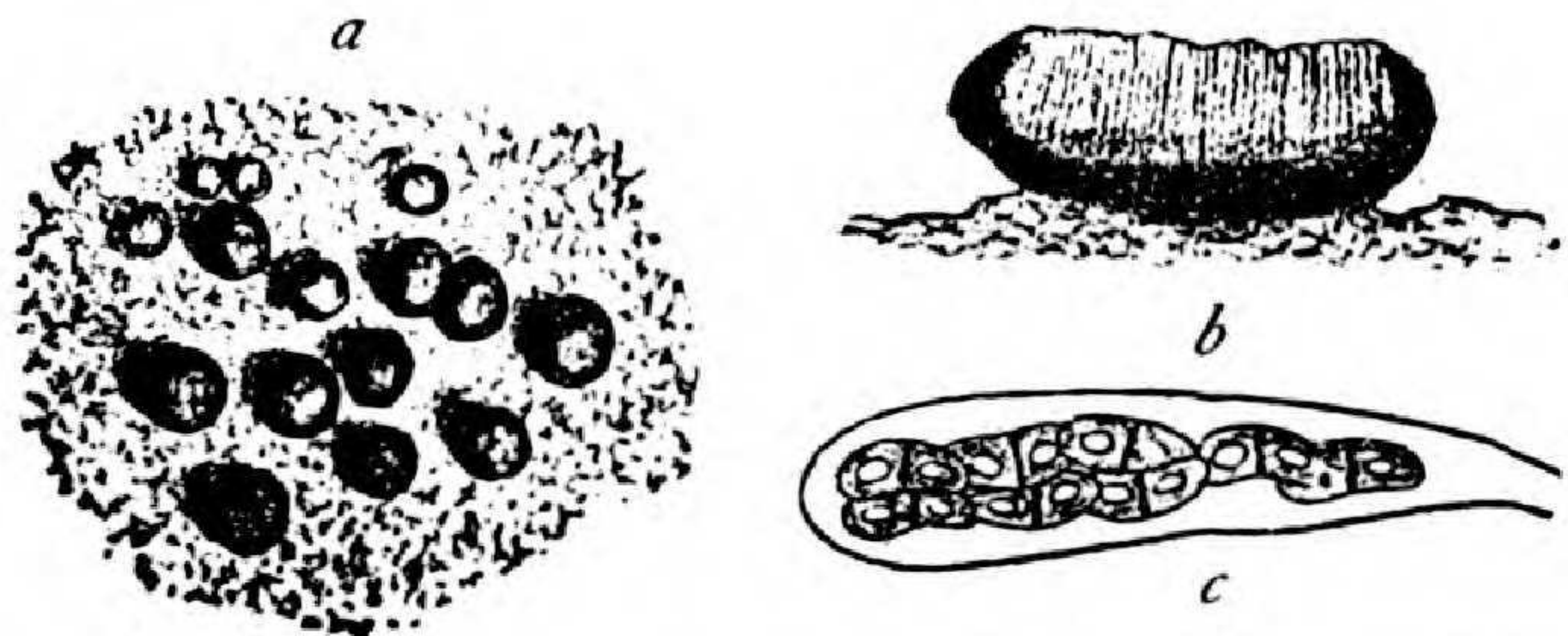


FIG. 11.—*Buellia myriocarpa*. a, Apothecium; b, vertical section of apothecium showing the dark exciple; c, ascus containing spores. a, Enlarged 4 diameters; b, 40 diameters; c, 450 diameters. From Reinke.

^a Lich. Scand. 594. 1871.

yellowish below and darker above in ours; paraphyses distinct or somewhat coherent, rarely branched, commonly enlarged and brownish toward the apex; asci clavate or narrowly clavate; spores brown, ellipsoid, 9 to 13 μ long and 3 to 6 μ wide.

Collected on the northern boundary at Rainy Lake City. On the thallus of *Baeomyces byssoides*.

Elsewhere in North America in Vermont and Newfoundland. Known also in Europe.

8. *Buellia inquilina* Tuck. Lich. Calif. 32. 1866.

Parasitic and no thallus discernible except that of the host; apothecia minute, 0.2 to 0.5 mm. in diameter, sessile or somewhat immersed, the disk black or brownish black, flat or somewhat convex, the exciple black and prominent or finally disappearing in ours; hypothecium dark brown; hymenium pale; paraphyses rarely branched, commonly thickened and brownish toward the apex; asci clavate; spores brown, ellipsoid, 10 to 18 μ long and 6 to 8 μ wide.

Collected at Warroad, on the northern boundary. On *Lecanora cinerea*, the host thus differing from that of Tuckerman, as likewise the plant differs somewhat in form and size of the apothecia.

Known elsewhere in Pennsylvania, North Carolina, South Carolina, and Texas. A strictly North American lichen.

9. *Buellia parmeliarum* (Sommerf.) Tuck. Syn. N. A. Lich. 2: 106. 1888.

Lecidea parmeliarum Sommerf. Suppl. Fl. Lapp. 176. 1826.

Parasitic, and no thallus discernible except that of the host, this commonly distorted and forming small tufts and lobules of unusual form, the color also often changed; apothecia minute, 0.2 to 0.5 mm. in diameter, the disk black or brownish black, flat or more commonly convex, the exciple prominent and black but commonly disappearing; hypothecium brown, varying toward blackish; hymenium pale to pale brownish below and brownish or brown above; paraphyses sometimes branched, commonly enlarged and brownish toward the apex; asci cylindrico-clavate; spores oblong-ovoid to ellipsoid, brown, 10 to 15 μ long and 3 to 6 μ wide.

Common in the northern portion of the State. On *Parmelia saxatilis* and *P. borrieri* on cedars in swamps.

Elsewhere in North America in New England, Nebraska, California, and Newfoundland, and at Bering Strait. Known also in Europe and Africa.

10. *Buellia parasitica* (Floerke) Tuck. Gen. Lich. 188. 1872.

Lecidea parasitica Floerke, Deutsch. Lich. no. 101. 1819.

Parasitic and showing no thallus except that of the host plant; apothecia minute, 0.2 to 0.6 mm. in diameter, sessile, the disk flat or rarely becoming slightly convex, black and oftener variously plicate when the apothecium becomes irregular in form, the exciple thin and rarely disappearing in the plicate and irregular forms; hypothecium dark brown; hymenium commonly pale below and brown or brownish above; paraphyses simple or rarely branched, frequently enlarged and brownish toward the apex; asci clavate; spores 4-celled, brown, ellipsoid or oblong, 10 to 16 μ long and 3 to 6 μ wide.

Collected in the northern part of the State at Oak Island, Harding, and Tower. On *Pertusaria communis* and *Lecanora pallescens*.

Also known in North America in California and Oregon, and at Bering Strait. Found also in Europe and New Zealand.

11. *Buellia glaucomaria* (Nyl.) Tuck. Syn. N. A. Lich. 2: 108. 1888.

Lecidea glaucomaria Nyl. Nya Bot. Notis. 177. 1852.

Parasitic and showing no thallus except that of the host plant; apothecia minute, 0.25 to 0.65 mm. in diameter, sessile, sometimes clustered and heaped, the disk flat and black, the exciple thick and seldom disappearing; hypothecium dark brown;

hymenium also commonly dark in section; paraphyses not distinctly seen in ours; asci clavate; spores 4-celled, brown, oblong-ellipsoid, 21 to 28 μ long and 7 to 9 μ wide.

Collected along the northern boundary at Warroad. On *Pertusaria* sp. on birch.

Elsewhere in North America in Greenland. Known also in northern Asia.

12. *Buellia badioatra* (Floerke) Koerb. Syst. Lich. 223. 1855.

Lecidea badioatra Floerke in Spreng. Neu. Entd. 2: 95. 1821.

Thallus verrucose or more commonly chinky-areolate, the areoles usually convex and wart-like, scattered upon the black so-called hypothallus or crowded and forming a continuous crust, varying in color from gray to brownish or reddish brown, irregularly and often widely spread over the substratum; apothecia small, 0.3 to 0.75 mm. in diameter, immersed and adnate, the disk flat or slightly convex, black, the exciple black, hardly raised above the disk and scarcely noticeable except in section; hypothecium dark brown; hymenium pale below and dark brown above; paraphyses coherent or becoming semidistinct, simple or rarely branched; asci clavate or inflated-clavate; spores brown, ellipsoid or oblong-ellipsoid, often somewhat constricted at the septum, 25 to 38 μ long and 11 to 17 μ wide, surrounded by a halo.

Collected on Blueberry Island in Lake of the Woods. On rocks. Externally quite like *Rhizocarpon petraeum*, of which it may yet prove to be but a 2-celled condition.

Elsewhere in North America in Greenland and Newfoundland. Known also in Europe.

The position of the species after the 4-celled species may well be questioned, but on the whole it seems nearest to *Rhizocarpon*.

RHIZOCARPON^a Ram. in Lam. & DC. Fl. Fr. ed. 3. 2: 365. 1805.

The thallus is commonly crustose, though tending toward squamulose conditions in one or two species, on the whole better developed than in *Buellia*, as shown in the more conspicuously verrucose and areolate conditions and the absence of granulose forms, but scarcely showing cellular cortex in any of the species, nor with distinguishable algal or medullary layers. It lies plainly above the substratum, to which it is attached by hyphal rhizoids, is on the whole considerably thicker and more conspicuous than the thalli of *Buellias*, and never entirely disappears, at least not in any of our species. The algal symbiont is as in *Buellia*.

In form, position relative to the thallus, color, and nature of the disk and exciple, the apothecia are much the same as in the *Buellias* and *Lecideas*, but they are on the whole rather larger. The spores are peculiar in that, while they usually become brown or blackish brown, they are often persistently colorless, so that we find the colorless and the brown spores in the same species and even in the same section, and often apparently the colorless ones quite as mature as the brown ones. The mature spores are 4-celled and muriform and usually surrounded by a halo. It remains to be demonstrated that the spores pass from a 2-celled condition to the muriform condition in any of the species placed here.

The present genus is closely related to *Buellia*, from which it has been separated on account of the spore characters, this being the more common method of European lichenists. The close relationship of the two genera is perhaps best seen in *Buellia badioatra*, which shows quite as many characters of the present genus. We have admitted to the genus *Buellia* two species with 4-celled spores rather than recognize as a third genus *Dactylospora* Koerb.^b

Nine species and subspecies occur in the State. On rocks.

Type species *Rhizocarpon geographicum* (L.) DC. loc. cit.

^aThe original spelling is followed.

^bSyst. Lich. 271. 1855

KEY TO THE SPECIES.

Thallus whitish or ashy.

Thallus inclined to rounded forms.

Apothecia frequently concentrically arranged; spores
22 to 39 μ long and 11 to 16 μ wide..... 3. *R. calcareum*
concentricum.

Apothecia not concentrically arranged; spores 12 to 22
 μ long and 4 to 9 μ wide 1a. *R. alboatrum*
saxicolum.

Thallus not inclined to rounded forms, but widely spread
and thin; spores as in the last above..... 1. *R. alboatrum.*

Thallus not whitish or ashy (except sometimes in *R. ignobile*).

Thallus from greenish to bright yellow..... 5. *R. geographicum.*

Thallus from dark ashy to brownish black.

Apothecia immersed.

Spores always becoming muriform, rather large... 2a. *R. petraeum*
grande.

Spores rarely muriform, smaller..... 4. *R. ignobile.*

Apothecia not always immersed.

Apothecia immersed or adnate.

Spores 8 in each ascus..... 2. *R. petraeum.*

Spores 1 or 2 in each ascus..... 2b. *R. petraeum*
montagnaei.

Apothecia adnate or somewhat immersed..... 2c. *R. petraeum ob-*
scuratum.

**1. *Rhizocarpon alboatrum* (Hoffm.) Th. Fr. Nov. Act. Reg. Soc. Sci. Ups. III.
3: 337. 1861.**

Lichen alboater Hoffm. Enum. Lich. Icon. 30. 1784.

Thallus ashy-gray, whitish or white, commonly widely spread over the substratum as a continuous crust but sometimes scattered or rarely disappearing, at first smooth but becoming chinky and verrucose-areolate and even rarely mealy; apothecia rather small, 0.3 to 1 mm. in diameter, adnate or immersed, the disk dull black or more or less white-pruinose, flat or becoming convex, the exciple black and commonly disappearing; hypothecium blackish brown; hymenium pale or pale brownish below and darker above; paraphyses simple or rarely branched, commonly enlarged and brownish toward the apex; asci clavate; spores brown, 4-celled and becoming muriform, 12 to 22 μ long and 4 to 9 μ wide.

Quite common in the northwestern and southwestern portions of the State. On trees, especially elms.

Generally distributed throughout North America. Found also in Europe, Asia, and Africa.

Buellia alboatra of the preliminary reports.

1a. *Rhizocarpon alboatrum saxicola* (Fr.) Fink.

Lecidea alboatra saxicola Fr. Lich. Eur. 337. 1831.

Thallus thicker and more inclined to rounded forms upon the substratum.

Collected at Mankato and at Rainy Lake City. On limestone and igneous rocks.

Widely distributed in North America, but not yet reported from arctic regions.

Known also in Europe.

Buellia alboatra saxicola of the preliminary reports.

2. Rhizocarpon petraeum (Wulf.) Koerb. Syst. Lich. 260. 1855.

Lichen petraeus Wulf. in Jacq. Coll. Bot. 3: 4. pl. 6. f. 2a. 1789.

Thallus varying in color from dark ashy to sea-green and brownish or brownish black, smooth or more commonly more or less roughened, chinky, and verrucose-areolate, usually widely and irregularly disposed upon the substratum, and continuous or scattered upon the commonly distinct and black so-called hypothallus, varying considerably in thickness, the areoles or verrucæ also varying in size in the various forms, but small or even minute; apothecia minute or middle-sized, 0.2 to 1.3 mm. in diameter, immersed or adnate, the disk black or blackish brown and flat or rarely somewhat convex, the exciple of the same color and at first elevated but frequently disappearing; hypothecium dark brown; hymenium pale or pale below and commonly brownish above; paraphyses commonly simple but sometimes branched, usually enlarged and brownish toward the apex; asci clavate or inflated-clavate; spores 4-celled and muriform, brown or hyaline, 15 to 40 μ long and 7 to 18 μ wide.

Occurring in all portions of the State except the southeastern. On igneous and metamorphic rocks.

Found throughout the northern portions of North America and well southward in the mountains. Known in all the grand divisions.

Buellia petraea of the preliminary reports.

The species varies greatly in the northern portion of the State, and in the last of the preliminary reports a number of subspecies were added on authority of A. Zahlbruckner and T. Hedlund. These forms are variously regarded by Europeans as species or subspecies, and the disposition and synonymy are in a hopeless tangle for the present. On the whole it seems best after further study to record some of the various forms here as subspecies of the above species without any hope of having made a final or even a clear disposition of all the difficulties.

2a. Rhizocarpon petraeum grande (Floerke) Fink.

Catocarpon grande Floerke, Flora 2: 690. 1828.

Thallus verrucose-areolate, the areoles swollen, ashy or violaceous brownish, usually scattered upon the conspicuous black hypothallus; apothecia immersed between the areoles, soon becoming very convex and subglobose; spores rather large.

Throughout the northeastern portion of the State and as far south as Taylors Falls. Habitat as above.

North American distribution the same as that of the species. Known also in Europe.

Buellia petraea grandis of the preliminary reports.

2b. Rhizocarpon petraeum montagnaei (Flot.) Fink.

Rhizocarpon montagnaei Flot.; Koerb. Syst. Lich. 258. 1855.

Thallus as above, but the spores only one or two in each ascus and of the largest size given for the species.

In all parts of the State where the species is known. Habitat as usual.

A strictly North American subspecies with same general range as the species.

Buellia petraea montagnaei of the preliminary reports.

2c. Rhizocarpon petraeum obscuratum (Ach.) Fink.

Lecidea petraea obscurata Ach. Lich. Univ. 156. 1810.

Thallus thin, minutely areolate with flat areoles, ashy or pale brownish, the hypothallus commonly poorly developed or absent; apothecia adnate or somewhat immersed, the exciple thick and persistent around the commonly flat disk; spores persistently hyaline or only slightly colored.

Collected at Kettle Falls. On rocks.

Elsewhere in North America in Newfoundland. Known also in Europe.

Buellia obscurata of the preliminary reports.

3. *Rhizocarpon calcareum concentricum* (Dav.) Th. Fr. Lich. Scand. 2: 632. 1874.

PLATE 8, A.

Lichen concentricus Dav. Trans. Linn. Soc. Lond. 2: 284. 1794.

Thallus white or whitish, smoothish or becoming chinky and finally areolate with quite minute areoles, in ours frequently disposed in more or less circular areas upon the substratum, the areas not more than 3 to 5 cm. in diameter; apothecia frequently showing a well-defined concentric arrangement, said to be 1 to 1.5 mm. in diameter, but only 0.3 to 1 mm. in ours of this subspecies, immersed or adnate, the disk flat and dull black or dark brown, rarely whitish-pruinose, the exciple dull black and persistent; hypothecium dark brown; hymenium pale below and brownish above; paraphyses coherent or becoming distinct, simple or branched, thickened and brownish toward the apex; asci clavate or inflated-clavate; spores hyaline or brown, muriform in ours, said to be at first 4-celled, 22 to 39 μ long and 11 to 16 μ wide.

The suborbicular thallus and the concentric arrangement of the apothecia are the special marks of the subspecies and to this may be added that the disk is said to be sometimes concave.

Collected at Rainy Lake City and at Kettle Falls. On rocks. Also at Grand Marais, and not previously reported from this locality, where the likeness given herewith was secured.

Not known elsewhere in North America. Found also in Europe.

The material from Grand Marais, determined by T. Hedlund, is plainly marked, and distinct from any form of *Rhizocarpon petraeum*, but I am disposed to think that all the forms recorded in the preliminary reports as *Buellia concentrica* belong to that species.

EXPLANATION OF PLATE 8.—A, Plant of *Rhizocarpon calcareum concentricum* on rocks, showing the orbicular crustose thallus and the concentrically arranged apothecia. B, Plant of *R. geographicum* on rock, showing the areolate crustose thallus and the immersed apothecia. A enlarged $2\frac{1}{2}$ and B 3 diameters.

4. *Rhizocarpon ignobile* Th. Fr. Lich. Scand. 2: 619. 1874.

Thallus ashy or ashy brownish, chinky or minutely verrucose-areolate, continuous or scattered upon the black hypothallus, more or less circular in small areas or more widely and irregularly distributed over the substratum; apothecia commonly immersed, small or minute, 0.3 to 0.7 mm. in diameter, the disk dull black, flat or becoming convex, the exciple black and frequently disappearing; hypothecium dark brown; hymenium pale, or pale below and brownish above; paraphyses frequently cohering, simple or branched, commonly enlarged and brownish toward the apex; asci clavate or inflated-clavate; spores in ours most frequently 2-celled, but passing into 4-celled and rarely into muriform conditions, hyaline, 14 to 20 μ long and 6 to 11 μ wide.

Determined by A. Zahlbruckner from Grand Portage Island and not previously reported from Minnesota. On rocks. Also, the plant from Rainy Lake City recorded as *Buellia concreta* in the last preliminary report seems to belong here. This was also determined by Doctor Zahlbruckner.

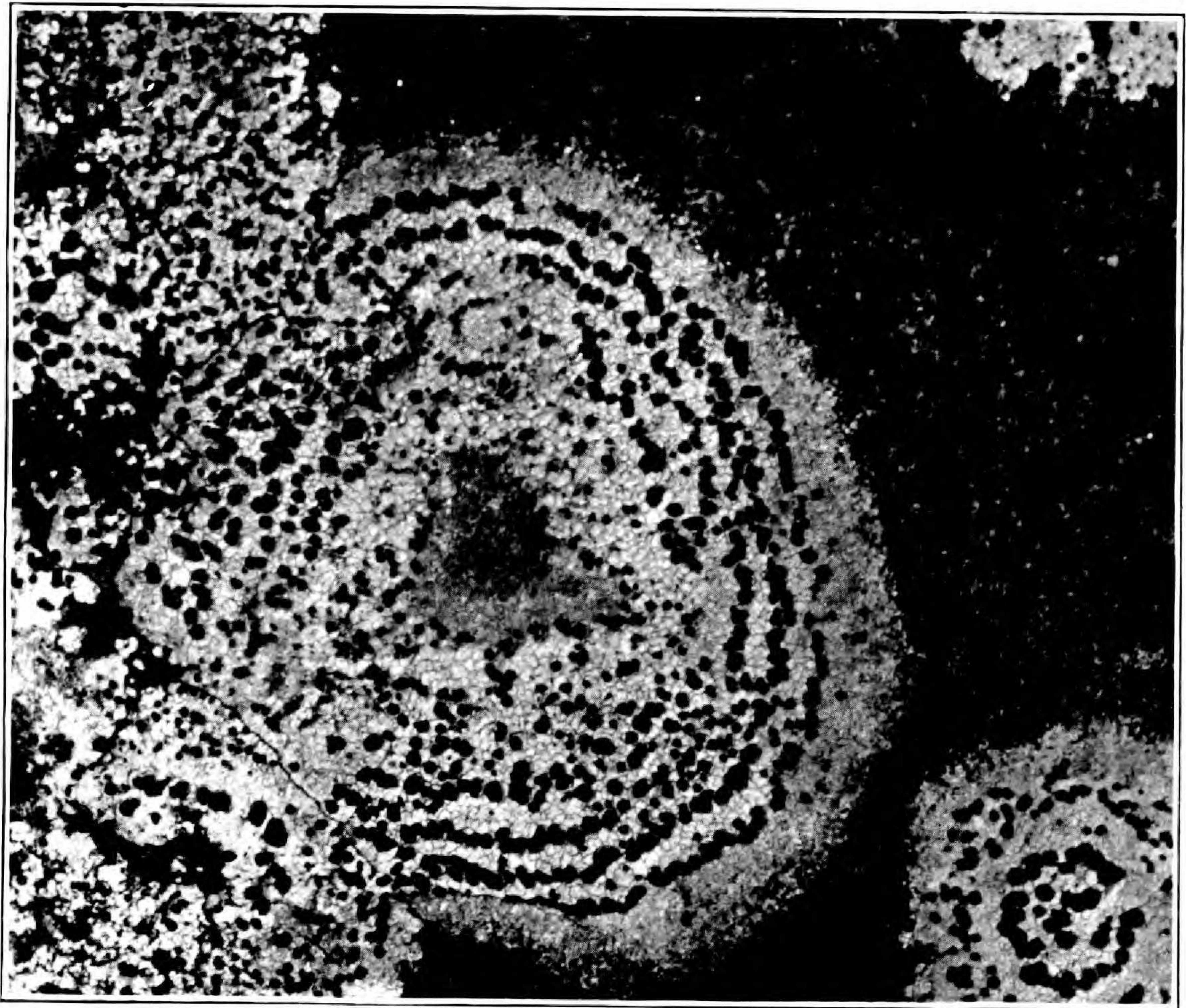
Rhizocarpon concretum is known from Newfoundland, but *R. ignobile* has not been previously reported from North America. Found also in Europe.

5. *Rhizocarpon geographicum* (L.) Lam. & DC. Fl. Fr. ed. 3. 2: 365. 1805.

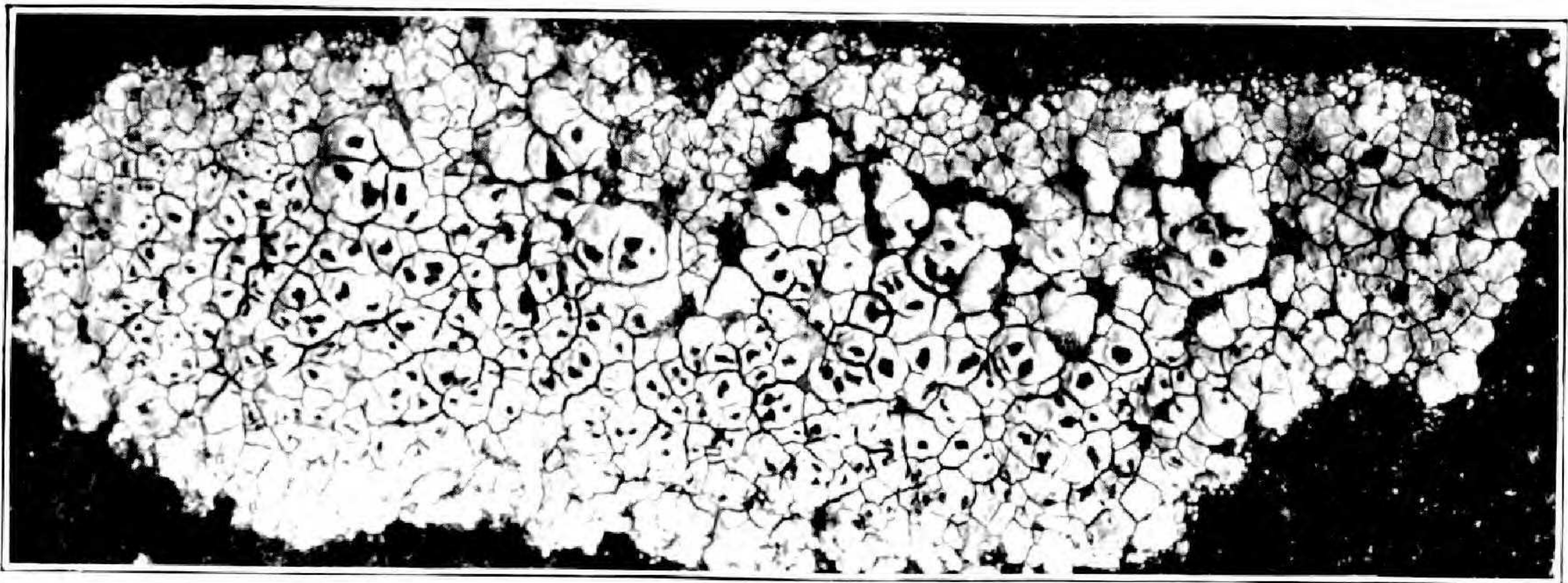
PLATE 8, B.

Lichen geographicus L. Sp. Pl. 1607. 1753.

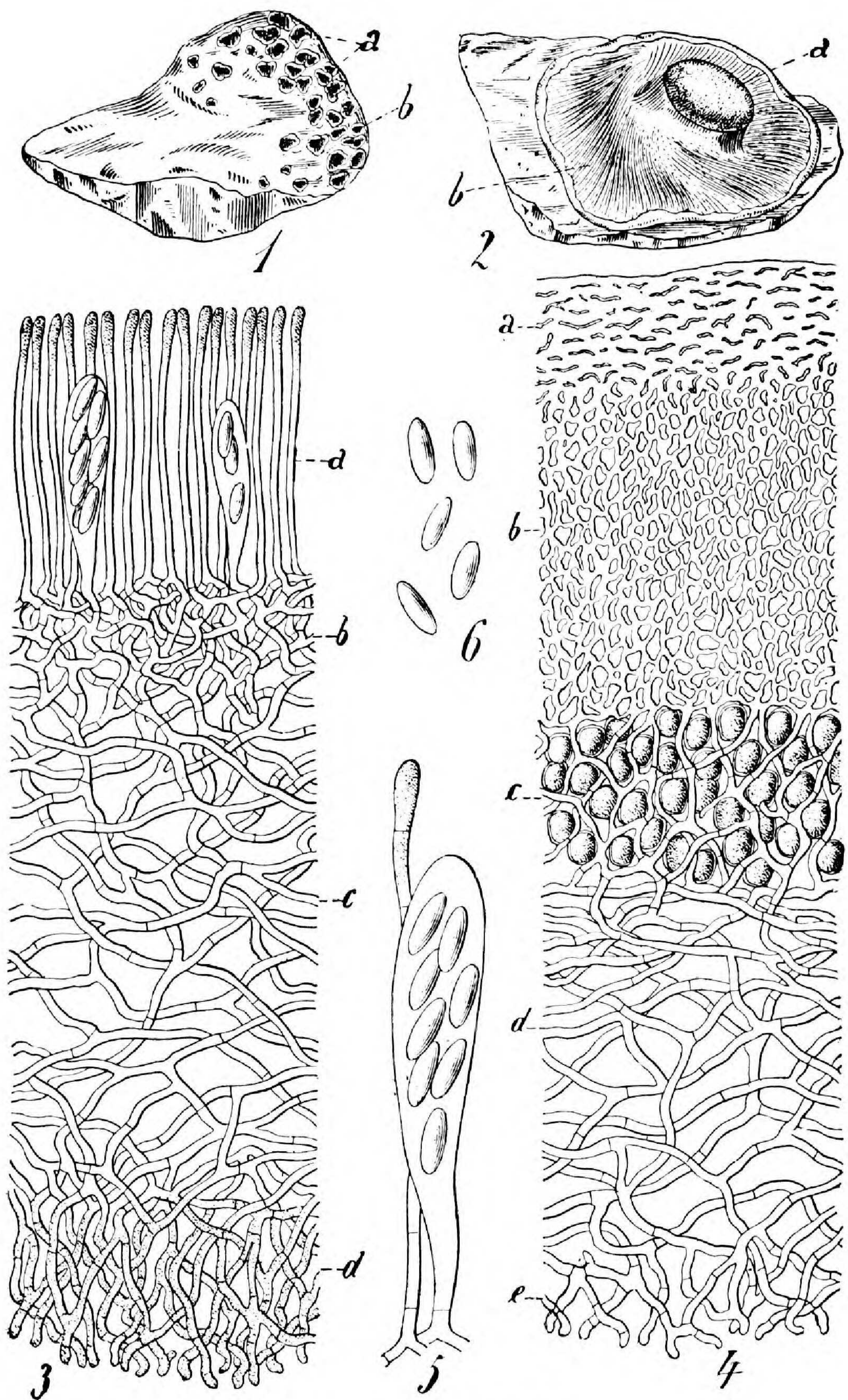
Thallus greenish to bright yellow upon a black hypothallus, composed of small areoles scattered over the substratum upon the conspicuous hypothallus or crowded into a continuous crust, in the latter case sometimes verrucose or chinky rather than distinctly areolate, the areas upon the substratum often quite small; apothecia small, 0.4 to 1 mm. in diameter, often crowded together in groups, and then angulate, in the more continuous forms of thalli immersed between the areoles or in the thallus, the disk black and flat or convex, the exciple black and somewhat prominent, but often disappearing; hypothecium dark brown; hymenium pale, or pale below and brownish



A. RHIZOCARPON CALCAREUM CONCENTRICUM (DAV.) TH. FR.



B. RHIZOCARPON GEOGRAPHICUM (L.) LAM.



PSORA RUSSELLII (TUCK.) FINK.

above; paraphyses distinct or cohering, sometimes branched and frequently thickened and brownish toward the apex; asci clavate or inflated-clavate; spores 2 to 4-celled and becoming muriform, hyaline to blackish brown, 18 to 38 μ long and 10 to 17 μ wide.

Occurring rarely in the extreme northern portion of the State. On rocks.

Throughout British America and Alaska and occasionally noted in the northern United States and southward in the mountains. Known in all the grand divisions.

Buellia geographica of the preliminary reports.

EXPLANATION OF PLATE 8.—See page 100.

Family PSORACEAE.

This is a small family closely related to the last. Indeed, it may well be doubted whether there is sufficient reason for separating the Psoraceae from the Lecideaceae. In the present family the thallus is squamulose or squamulose-crustose with a well-developed cellular cortex above, while in the Lecideaceae there is rarely any suggestion of a squamulose condition, and in these best states there is only rarely a suggestion of a cellular cortex, never one sufficiently developed to form a continuous layer.

The apothecia are similar to those of the last family, but there is never any thaloid exciple. The algal symbiont is *Cystococcus*. The spores do not show so wide a range of structure as in the Lecideaceae, the brown and muriform forms being wanting.

Externally the thalli resemble those of certain *Dermatocarpon*s, but there is no close relationship between that genus and members of the present family.

Two genera and several species and subspecies of the family occur in the State, on rocks or earth. The first genus seems to stand between section *Biatora* and *Cladonia*, while the second is nearest to *Eulecidea*, except for the spores, which are nearer to those of *Bilimbia*.

PSORA Hoffm. Descr. Pl. Crypt. 1: 37. pl. 8. f. 1 (et seq.) 1790.

PLATE 9.

The thallus is composed of squamules, each of which is to be regarded as a small foliose structure. These squamules are of various forms and may be scattered or may be run together into a continuous crustose or foliose thallus. The upper cortex is well developed and thick and shows a more or less well-defined cellular structure in all of the species. The lower cortex may be entirely wanting, or there may be a pseudocortex of hyphæ extending for most part in a horizontal direction. The algal layer is always well represented. When the pseudocortex is present on the lower side, it replaces the medullary layer. The upper cellular cortex is more or less gelatinized and the cell lumina correspondingly reduced, and the gelatinization may go so far as completely to obliterate the cellular structure, especially in the upper portion of the cortex. The algal symbionts are doubtless a form of *Cystococcus*. The color of the thallus varies greatly. The squamules are attached to the substratum by more or less numerous hyphal rhizoids; and they may be flat and closely attached throughout, or the margins may be ascendant.

The apothecia are variously disposed over the surface of the squamules and are rather small and adnate or sessile. The proper exciple is evanescent or soon overgrown in all of our species and is therefore seldom seen. The color is most commonly a brown or black. The hypothecium is usually more or less brown, and the hymenium pale or somewhat colored. The paraphyses are commonly simple, but branched forms may be found in any of our species. The spores are simple, ellipsoid in form, and hyaline.

In apothecial and spore characters the present genus is plainly most closely related to *Lecidea*, but the thallus is much better developed than in any member of that

genus and reminds one of that of *Toninias* and also of the primary thallus of most *Cladonias*. Thus the genus seems to be related below with *Lecidea* and above with *Cladonia*, probably having been derived from members of the former genus and perhaps leading up to certain ones of the latter.

Five species and subspecies occur in the State. Commonly on earth or rocks.

Type species *Psora caesia* Hoffm. loc. cit. But this is a *Physcia*, doubtless *P. caesia* (Hoffm.) Nyl. This, therefore, gives *Psora* precedence over *Physcia*, but *Psora* Hoffm. is anticipated by *Psora* Hill, 1769, a genus of *Asteraceae*.

EXPLANATION OF PLATE 9.—Fig. 1, *a*, a portion of the thallus; *b*, an apothecium. Fig. 2, *a*, an apothecium; *b*, a portion of the thallus. Fig. 3, a section through an apothecium and the underlying thallus; *a*, the hymenium; *b*, the hypothecium; *c*, the medullary layer; *d*, the hyphal rhizoids. Fig. 4, a section of the thallus; *a*, the dermis; *b*, the upper cortex; *c*, the algal layer; *d*, the medullary layer; *e*, the hyphal rhizoids. Fig. 5, a paraphysis and an ascus. Fig. 6, free simple spores. Fig. 1, natural size; fig. 2, enlarged about 8 diameters; fig. 3, enlarged 300 diameters; fig. 4, enlarged about 425 diameters; figs. 5, 6, enlarged 650 diameters. From Schneider.

KEY TO THE SPECIES.

Thallus brownish to blackish; on rocks.

Thallus brownish olivaceous and darker, ascendant..... 1. *P. rufonigra*.

Thallus dull brown to reddish brown, white-edged, adnate,
or ascendant at the margin..... 2. *P. russellii*.

Thallus not brownish or blackish; on earth.

Thallus white, adnate..... 3a. *P. decipiens de-
albata*.

Thallus not white.

Thallus incarnate brick-colored, closely adnate, white-
edged..... 3. *P. decipiens*.

Thallus greenish yellow or finally tawny..... 4. *P. icterica*.

1. *Psora rufonigra* (Tuck.) Fink.

Biatora rufonigra Tuck. Syn. Lich. N. E. 58. 1848.

Thallus composed of brownish or more commonly olivaceous or even blackish, scattered or more or less clustered and imbricate, irregular or round-lobed, commonly ascendant, somewhat concave, smooth squamules, these rather small, 0.5 to 1.5 mm. in diameter, commonly darker along the margins and below, clothed below with dark hyphal rhizoids; below the algal layer of the thallus a layer of densely interwoven hyphæ, to be regarded as a pseudocortex rather than a medulla; apothecia rather small, 0.3 to 1 mm. in diameter, adnate, in ours at least black, though said to be sometimes dark rufous, rarely flattish and margined by an exciple, but more commonly convex and immarginate; hypothecium pale; hymenium pale or darkening, especially above; paraphyses simple or rarely branched, commonly dark and enlarged toward the apex; asci clavate; spores oblong-ellipsoid, 8 to 15 μ long and 5 to 7 μ wide.

The plant is the most widely distributed member of the genus in the State, and may be looked for in all portions except the southeastern. On the Archæan or Algonkian rock exposures. Though the most widely distributed, this lichen is by no means common. Thus far, in Minnesota, it has always been met with growing on rocks with an alga resembling *Sirosiphon* in external appearance.

The species is widely distributed in the United States and extends northward into British America. A strictly North American plant.

Biatora rufonigra of the preliminary reports.

2. *Psora russellii* (Tuck.) Fink.

PLATE 9.

Lecidea russellii Tuck. Proc. Amer. Acad. 5: 417. 1862.

Thallus composed of rather thick, dull or reddish brown, scattered or more or less clustered, closely adnate or marginally ascendant, rounded or more or less lobed and

irregular, sometimes reticulately furrowed, white-edged squamules, larger than those of the above, 1 to 3.5 mm. in diameter, white beneath; pseudocortex below scarcely any, the hyphal rhizoids rather few, usually situated toward the center of the thallus; apothecia of about the same size as in the last, or perhaps somewhat larger, sessile, commonly convex and the paler margin disappearing, reddish brown and darkening; hypothecium yellowish or light brown; hymenium pale yellowish to brownish, lighter below; paraphyses simple, or rarely branched toward the commonly enlarged and brownish apex; asci cylindrico-clavate; spores ellipsoid, 9 to 13 μ long and 4 to 6 μ wide.

The plant here reported was collected at La Crosse, Wisconsin, by L. H. Pammel, but of course the same occurs on the Minnesota side. On calcareous rocks. Quite common in northeastern Iowa and no doubt also in southeastern Minnesota.

Widely distributed in the United States and northward into British America. A North American plant.

Biatora russellii of the preliminary reports.

3. *Psora decipiens* (Ehrh.) Hoffm. Descr. Pl. Crypt. 2: 63. pl. 43. f. 1-3. 1794.

Lichen decipiens Ehrh. in Hedw. Descr. Musc. Frond. 2: 7. 1789.

Thallus composed of incarnate brick-colored, scattered or rarely somewhat clustered, closely adnate, rounded or somewhat irregular and lobed, entire or in ours frequently delicately crenulate-margined, more or less concave and sometimes furrowed, white-edged squamules, which are thinner and somewhat smaller than those of the last, 0.75 to 3 mm. in diameter, and white below; thallus microscopically similar to the last; apothecia slightly smaller than in the last, 0.3 to 1.2 mm. in diameter, sessile or adnate, commonly marginal and sometimes oblong, brown and becoming black, usually strongly convex and the lighter margin absent; hypothecium brown or brownish; hymenium pale brownish or reddish brown; paraphyses simple or rarely branched toward the apex, there usually enlarged and brownish; asci clavate; spores oblong-ovoid, 10 to 16 μ long and 5 to 7 μ wide.

Collected at Granite Falls, at Battle Lake, and in the Leaf Hills. On calcareous earth. No doubt occurs also with the last in southeastern Minnesota, but always on earth. The differences between the present and the last species above are easily seen in the plants, though not easy to demonstrate in the descriptions.

Widely distributed in North America, but not known at the extreme south. Known from all the grand divisions except South America.

Biatora decipiens of the preliminary reports.

3a. *Psora decipiens dealbata* (Tuck.) Fink.

Biatora decipiens dealbata Tuck. Syn. N. A. Lich. 2: 13. 1888.

As the above, except that the thallus is white. It may well be doubted whether this should be recognized as a subspecies simply on the basis of the color difference.

Collected with the above at Granite Falls and in the Leaf Hills. The same occurs in Iowa and may be looked for wherever the species occurs.

Biatora decipiens dealbata of the preliminary reports.

4. *Psora icterica* (Mont.) Fink.

Biatora icterica Mont. Ann. Sci. Nat. Bot. II. 2: 373. 1834.

Thallus composed of greenish, yellowish, or finally tawny squamules, these scattered or areolately or imbricately clustered, closely adnate, but frequently somewhat raised and paler-edged, sometimes rounded but more frequently radiately or irregularly lobed, flat or concave, smooth or furrowed, ventrally white, 1 to 4 mm. in diameter in ours (Tuckerman says hardly so large as in the last); thallus showing the pseudocortex below much as in our first species of the genus; apothecia small to middle-sized, 0.3 to 1.2 mm. in diameter, closely sessile, dark brown and blackening,

the disk commonly convex and without margin; hypothecium pale brownish to brown; hymenium light brown; paraphyses simple or rarely branched, commonly thickened and brownish toward the apex; asci clavate; spores ovoid-ellipsoid, 12 to 18 μ long and 4 to 7 μ wide.

Collected at Granite Falls. Tuckerman also records the plant from the State, collected by Lapham, but without locality. On earth.

Widely distributed in the United States west of the Mississippi River, and also collected in New York and in British Columbia. A strictly American plant, also widely distributed in South America.

Biatora icterica of the preliminary reports.

TONINIA Mass. Ric. Lich. 107. *f.* 212-214. 1852.

The thallus is squamulose-crustose, squamulose, or even subareolate, and is usually lobed at the margin. So far as we have been able to examine the species, the upper cortex is rather thin, but cellular, and the algal and medullary layers are more or less differentiated. No lower cortex is developed. The upper cortex is usually considerably gelatinized and the cells may be completely obliterated, especially toward the upper portion. The algal symbiont is *Cystococcus*. White, ashy, sea-green, brown, and olivaceous are common colors. Hyphal rhizoids attach the thallus to the substratum. On the whole, the thalli remind one of those of the *Psoras*, and they may consist of scattered squamules or may be continuous with the squamules more or less imbricated. The apothecia are scattered over the squamules and are usually black, small, and adnate or sessile. The proper exciple is commonly dark, but may be lighter and more like that of the section *Biatora* than that of *Eulecidea*. It usually soon disappears, leaving the apothecium without margin. The hypothecium varies from pale to dark brown and the hymenium also may be more or less brownish throughout. The asci are clavate or rarely cylindrico-clavate. The spores are hyaline, 4 to 8-celled, and oblong or ellipsoid.

The present genus is nearest to *Psora* as to thallus structure, but nearer to *Bilimbia* as to spores, and on the whole doubtless nearest to *Eulecidea* as to character of the apothecium or more especially the exciple. Species having 2-celled spores are by some admitted to the genus, but we have followed Massalongo in excluding them.

A single species has been met in the State. On mossy rocks.

Type species *Toninia cinereovirens* (Schaer.) Mass. loc. cit.

Toninia aromatica (J. E. Smith) Mass. *Symm. Lich.* 54. 1855.

Lichen aromaticus J. E. Smith in Sowerby, *Engl. Bot.* 25: *pl.* 1777. 1807.

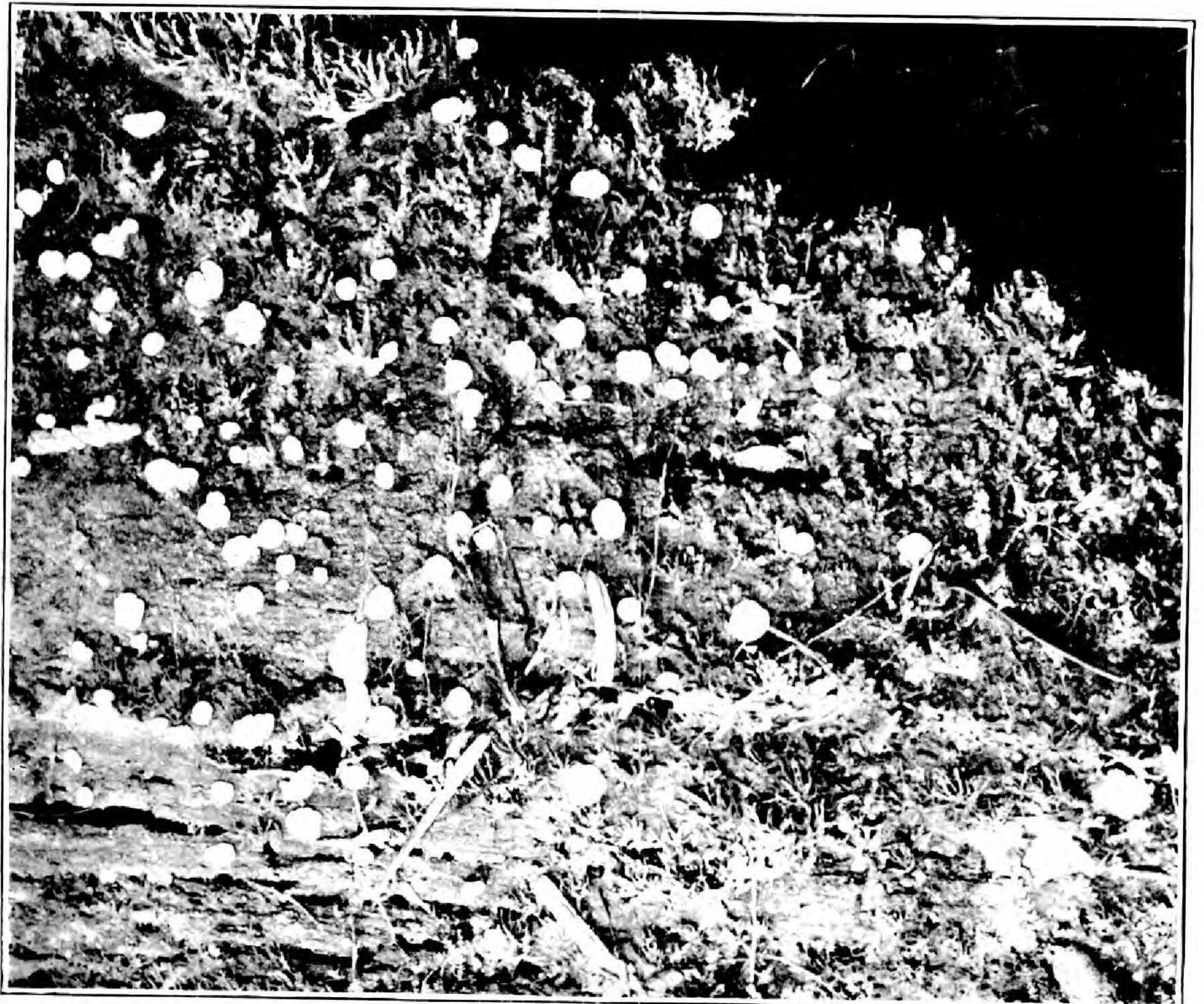
Thallus composed of rather small, contiguous or more or less scattered, verruca-like squamules, 0.5 to 2 mm. in diameter, when closely clustered forming a subverrucose crust, the squamules thickened and commonly more or less irregular, the crust, when continuous, somewhat irregular and covering areas of the substratum 10 to 35 mm. in diameter, olivaceous varying toward brownish or ashy; apothecia small, adnate, 0.4 to 1 mm. in diameter, often clustered, the disk black, at first flat and surrounded by the black exciple, soon becoming convex and variously irregular, the exciple disappearing; hypothecium brown to blackish brown; hymenium commonly brownish throughout and darker above; paraphyses simple or more or less branched, often somewhat coherent, commonly enlarged and brownish toward the apex; asci clavate or cylindrico-clavate; spores fusiform to cylindrico-fusiform, 4-celled, 15 to 27 μ long and 3 to 4.5 μ wide.

Collected on mosses over rocks at Grand Marais. Not previously reported from Minnesota.

Reported from California and Ontario, but the California material is said to have simple spores and must be immature or of some other species. Known also in Europe and Africa.



A. *BAEOMYCES BYSSOIDES* (L.) ACH.



B. *ICMADOPHILA AERUGINOSA* (SCOP) MASS.

Family BAEOMYCETACEAE.

One of the two genera of this small group seems to stand out distinctly enough to warrant the recognition of the group as a family. This is the genus *Baeomyces*. Here we have a well developed stipe in company with apothecial characters related to those of the Lecideaceae rather than of the Caliciaceae, where the stipe is also found. It is apparent enough that the *Baeomyces* may have been evolved from the Lecideas by the development of a stipe. And, indeed, the relationship as to thallus, apothecia, and spores seems very close. But when we turn to the other genus, *Icmadophila*, we are confronted with difficulties which make it questionable whether that genus should be placed in the present family or with the Lecanoraceae. The relationships of the genus are discussed in connection with the description of it, and here it need only be said that the spore characters are such as might indicate a close relationship with *Biatorina* or *Bilimbia*, and that this fact adds weight to the present disposition of the genus.

The family is represented in the State by but two genera and as many species. Both species are found in the northern portion of the State.

BAEOMYCES Ehrh. Beitr. Naturk. 4: 149. 1789.

The thallus is commonly crustose, though in one North American and a few foreign species it reaches a subfoliose condition. In all of the crustose species, at least, the cortical layers are absent, though algal and medullary layers may usually be distinguished, the former usually covered above by a thin layer of gelatinized hyphæ. The hyphal rhizoids are few. The algæ are probably a modified form of *Cystococcus*, but *Gloeocapsa*-like colonies are also frequently found in some of the species. The apothecia are borne upon stipes, which are devoid of algal cells and thus more rudimentary structures than the podetia of the *Cladonias*. The stipes, accordingly, are composed entirely of hyphæ, those forming the outside being closely packed and running longitudinally, while those toward the central portions are more loosely and irregularly arranged.

The apothecia are single or more or less grouped upon the stipes. They are surrounded by a proper exciple, which may disappear when the disk becomes very convex. The hypothecium is commonly pale and the hymenium pale or brownish below and darker above. The spores are simple and colorless in the genus as here limited.

The members of the genus are clearly related to the *Cladonias* and the *Lecideas*, and scarcely more closely or certainly with *Icmadophila*, which genus is included with *Baeomyces* by Tuckerman.

A single species is found in the State. On rocks and earth.

Type species *Lichen baeomyces* L. f. Suppl. Pl. 450. 1781. (*Baeomyces roseus* Pers. Ann. Bot. Usteri 7: 19. 1794.)

Baeomyces byssoides (L.) Ach. Lich. Suec. 82. 235. 1798.

PLATE 10, A.

Lichen byssoides L. Mant. Pl. 1: 133. 1767.

Primary thallus crustose and rather thin, granulose, the rounded granules becoming leprose-squamose and crenate-lobulate, commonly widely and irregularly spread over the substratum as a continuous or more or less broken crust, sea-green or more commonly varying toward greenish or whitish; stipes unbranched (or rarely divided above) and scarcely ever more than 3 or 4 mm. long, usually shorter and sometimes scarcely developed; apothecia commonly convex-pileate, small to middle-sized, 0.7 to 1.75 mm. in diameter, the disk from brownish flesh-colored to dark brown, the exciple evanescent; hypothecium commonly pale; hymenium pale brownish below and darker above; paraphyses simple or frequently branched, commonly enlarged

and darker toward the apex; asci cylindrico-clavate; spores simple, oblong-ellipsoid, 8 to 15 μ long and 3 to 4 μ wide.

Found in a number of places in the northern portion of the State. On rocks and earth.

Elsewhere in North America in New York, New Hampshire, Oregon, North Carolina, and Florida, and in several places in British America. Within the United States usually in mountains. Known also in South America, Europe, and New Zealand.

EXPLANATION OF PLATE 10.—A, Plant of *Baeomyces byssoides* on rocks, showing the thallus and the stipes surmounted by apothecia. B, Plant of *Icmadophila aeruginosa* on a decorticated log, showing the thallus and the apothecia. A enlarged nearly 2½ diameters; B enlarged nearly 2¼ diameters.

ICMADOPHILA Ehrh. Beitr. Naturk. 4: 147. 1789.

In the single species known the thallus is crustose, usually widely spread over the substratum, to which it is closely attached, and scarcely showing any differentiation into layers. The algal symbiont is a modified form of *Cystococcus*, though *Gloeocapsa* may also appear in the association. The stipes are absent or very short, and if to be regarded as stipes at all, are solid throughout.

The apothecia are sessile or subsessile, of good size, and surrounded by a proper exciple, which may disappear. The proper exciple is in turn surrounded by a thalloid one, which is quite evanescent. The spores are 2 to 4-celled, hyaline, and fusiform.

The relationships of the genus are by no means certain. A comparison of the above description with that of *Baeomyces* will reveal considerable similarity, and yet perhaps the spore and apothecial characters would place the present genus quite as close to *Haematomma*. Also, the external resemblance to *Lecanora pallida* is very marked.

Type species *Lichen icmadophilus* L. f. Suppl. Pl. 450. 1781. (*Icmadophila aeruginosa* (Scop.) Mass.)

Icmadophila aeruginosa (Scop.) Mass. Ric. Lich. 26. 1852.

PLATE 10, B.

Lichen aeruginosus Scop. Fl. Carn. ed. 2. 2: 361. f. 42. 1772.

Primary thallus crustose, of medium thickness, roughened-granulate or rather verrucose, rarely becoming subleprose, usually widely spread over the substratum as a continuous crust, sea-green, varying toward greenish or whitish; apothecia sessile or borne on the rarely developed, very short stipes, middle-sized or larger, 0.6 to 3.5 mm. in diameter, rosy flesh-color or lighter, the disk flattish and commonly more or less wrinkled, surrounded by a rather thin proper margin, this in turn usually by more or less of a thalloid one, or the disk sometimes becoming convex and the excipular margin disappearing; hypothecium pale; hymenium of the same color or slightly darker above; paraphyses simple or rarely branched, sometimes slightly enlarged and colored above; asci cylindrico-clavate; spores oblong-fusiform, 2 to 4-celled, 14 to 28 μ long and 4 to 6 μ wide.

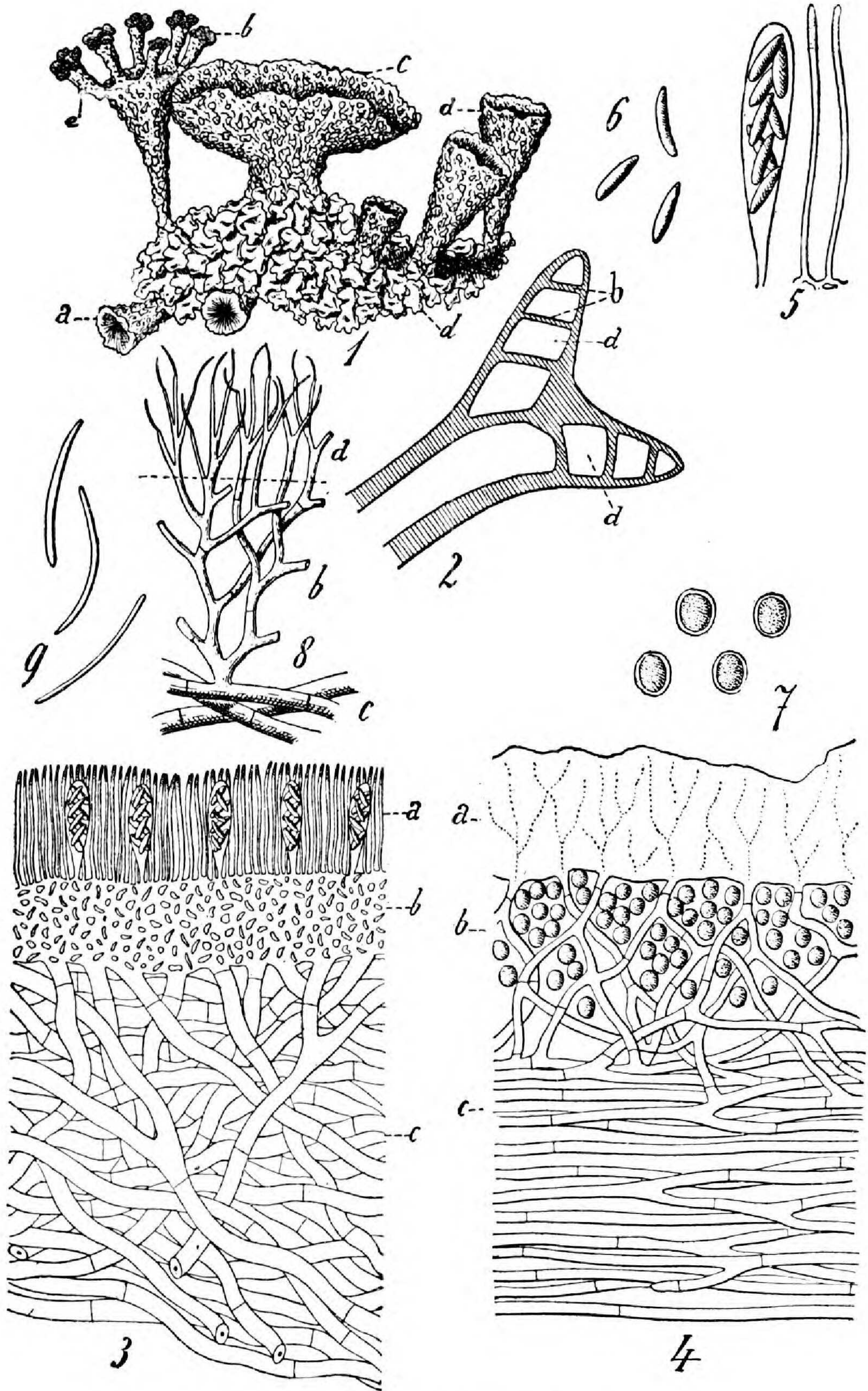
Generally distributed in the extreme northern portion of the State. On rotting wood.

Found throughout British America, in Oregon, and in the Rocky Mountains. Known also in Europe and Asia.

Baeomyces aeruginosus of the preliminary reports.

Family CLADONIACEAE.

The family within the limits of this volume consists of the single genus *Cladonia*. The structure of the thallus and apothecia will be thoroughly discussed in the description of the genus. The origin of stipes and podetia is similar in each ontogeny, and it may be assumed that the lichens showing the podetia have been derived phylogenetically from some such genus as *Baeomyces*, in which we have the stipes and also



CLADONIA PYXIDATA (L.) HOFFM.

very similar apothecial structure. Hence it would seem that the Cladonias are closely related to Baeomyces. Plainly enough Stereocaulon is also closely related to Cladonia, and we need not discuss here several other closely related genera not found in our flora.

Though the family consists of the single genus, this genus is the largest in our flora and contains nearly one-eighth of all of our lichens.

CLADONIA Hill; Web. in Wig. Prim. Fl. Hols. 90. 1280.

PLATE 11.

The thallus consists of a basal more or less ascendant and squamulose primary portion and an erect fruticose portion, constituting the podetia. The basal or primary thallus may depart from the typical foliose and ascendant form, being then crustose and horizontal, and when so is more or less roughened or verrucose. In structure, this portion of the thallus shows a pseudocortex on the upper side, but the lower side is without cortex and usually sorediate; or more rarely the cortex is wanting even above. This primary thallus consists of squamules which are exceedingly variable in form and size even in a given species, and it may be evanescent, so that it is seldom seen in such long-lived plants as Cladonias. The algal and medullary layers are usually more or less differentiated.

The podetia commonly arise from the surface of the squamules or verrucæ of the primary thallus, though the primary thallus may disappear and even the bases of the podetia die while the upper portion continues to grow, perhaps for centuries. These podetia may be simple and cylindrical, tubæform, trumpet-shaped, or variously irregular, or they may be branched and are frequently very much so. Their summits are frequently cup-shaped, and from the margins or central portions of the cups secondary podetia may arise, and from the cups of these tertiary, etc. These secondary and tertiary podetia are commonly called proliferations, and the lowest and original podetia form the first rank, the secondary podetia the second rank, the tertiary the third rank, etc. The podetia are thus in the form of more or less hollow cylinders and have the usual layers arranged radially. In both primary thallus and podetia the cortex is really a pseudocortex of interwoven and much gelatinized hyphæ, and in the podetia algal cells are few. The cortex may be partly or entirely absent from the podetia, when they are likely to be sorediate. When present, the cortex may be continuous, verrucose, areolate, or scattered-areolate. Squamules similar to those of the primary thallus frequently clothe the podetia to a greater or less extent. The central hyphæ of the podetium run approximately in the direction of the long axis. The algal symbiont is *Cystococcus*. As to attachment, hyphal rhizoids are more or less frequent, fastening the squamules, or perhaps rarely the basal end of the podetia, to the substratum. The squamules, and more especially the podetia, in these recently evolved lichens are so extremely variable that the Cladonias become the most difficult lichens to determine.

The apothecia are either terminal on the podetia or on their cups or branches, or short apothecial stalks may intervene. They vary considerably in size, form, and arrangement, and may have a flat disk and a thin biatoroid margin, or a convex disk which is commonly without a marginal exciple. The prevailing color of the disk is brown or scarlet, and the upper portion of the hymenium usually partakes more or less of these colors, while the lower portion and the hypothecium are paler. The paraphyses are simple or more rarely branched, and the asci are clavate or cylindriclavate, with the apical wall almost uniformly more or less thickened. The spores are simple, hyaline, ellipsoid, and so uniform in size and shape that no use is ordinarily made of them in the classification of species. Soredia are very common, though inconspicuous and easily overlooked.

The genus is closely related, as already noted, to *Stereocaulon*; also to *Thamnomia*, a genus consisting of a single species and not represented in our flora.

Cladonia is represented in the State by over 50 more or less distinct lichens. Our species occur on all sorts of substrata, but most commonly on earth or old wood.

The synonymy of the Cladonias was considerably changed during the progress of the preliminary reports, and is consequently quite different in the earlier papers of these reports from that used in this volume.

Type species *Cladonia polymorpha* Web. loc. cit. (*C. squamosa* (Scop.) Hoffm.)

EXPLANATION OF PLATE 11.—Fig. 1, the plant; *a* and *c*, sterile podetia; *b*, apothecia; *d*, the primary thallus; *e*, proliferations or branches. Fig. 2, a diagrammatic section of the cup of a podetium; *a*, cavities; *b*, mechanical tissue. Fig. 3, a section of an apothecium; *a*, the hymenium; *b*, the hypothecium. Fig. 4, a section of the primary or horizontal thallus; *a*, the cortex of gelatinized hyphæ; *b*, the algal layer; *c*, the hyphæ extending in the direction of growth, within a very thin medullary layer between *b* and *c*. Fig. 5, two paraphyses and an ascus with spores. Fig. 6, spores. Fig. 7, algal cells. Fig. 8, *a*, sterigmata, bearing spermatia; *b*, hyphal network below the sterigmata; *c*, tissue inclosing the spermatium. Fig. 9, spermatia. Fig. 1, natural size; fig. 2, enlarged about 15 diameters; fig. 3, enlarged 250 diameters; fig. 4, enlarged about 175 diameters; figs. 5-7, enlarged 650 diameters; fig. 8, enlarged 500 diameters; fig. 9, enlarged 1,600 diameters. From Schneider.

KEY TO THE SPECIES.

Section I. Plants large, the primary thallus disappearing; podetia much branched; apothecia rare.

Podetia large, sea-green to grayish or brownish, the sterile tips
nutant 1. *C. rangiferina*.

Podetia hardly so large.

Podetia stoutish, whitish, straw-colored, or sea-green..... 2. *C. sylvatica*.

Podetia more slender, whitish or yellowish straw-colored,
the sterile tips erect and brighter..... 3. *C. alpestris*.

Section II. Apothecia scarlet; podetia usually not conspicuously branched.

Cups present and well developed.

Primary thallus usually disappearing; podetia usually
longer and more slender than in the three following... 8. *C. deformis*.

Primary thallus usually persistent.

Squamules large..... 6. *C. digitata*.

Squamules much smaller.

Podetia corticate throughout..... 7. *C. coccifera*.

Podetia decorticate and soresiate toward the top..... 7a. *C. coccifera pleuro-
rota*.

Cups absent or poorly developed.

Podetia absent or short..... 9b. *C. cristatella pal-
udicola*.

Podetia well developed.

Podetia simple or rarely branched, usually decorticate.

Spores obliquely disposed; podetia rarely branched... 4. *C. bacillaris*.

Spores irregularly disposed; podetia more often
branched..... 5. *C. macilenta*.

Podetia somewhat more commonly and conspicuously
branched, corticate.

Podetia not densely squamulose..... 9. *C. cristatella*.

Podetia densely squamulose..... 9a. *C. cristatella ves-
tita*.

Section III. Apothecia brown; primary thallus usually evanescent; podetia for the most part conspicuously branched.

Podetia more or less decorticate and soresiate..... 12a. *C. furcata scabri-
uscula*.

Podetia corticate.

Podetia straw-colored, whitish, or sea-green.

Podetia not conspicuously squamulose, at least not throughout.

Tips straight and subulate.

Tips usually brown..... 10. *C. amaurocraea*.

Tips rarely brown.

Tips usually subulate; podetia stout..... 11. *C. uncialis*.Tips short and obtuse; podetia stout..... 11a. *C. uncialis obtusata*.Tips often recurved; podetia longer and more slender.. 12. *C. furcata*.

Podetia usually more or less squamulose throughout.

Tips and whole branches irregular..... 12c. *C. furcata finkii*.Tips and branches not irregular..... 12d. *C. furcata pinnata*.

Podetia not always straw-colored or sea-green.

Podetia brownish or olive-brown above..... 12b. *C. furcata paradoxa*.Podetia sea-green to reddish brown or olivaceous..... 13. *C. crispata*.

Section IV. Apothecia brown; primary thallus usually persistent; podetia for most part simple, or little branched.

Podetia becoming long.

Podetia always corticate.

Cortex continuous or closely areolate.

Podetia usually cupless; tips short-branched..... 19. *C. turgida*.

Podetia cup-bearing.

Proliferations from the centers of the cups..... 25. *C. verticillata*.Proliferations in part from the margins of the cups and the sides of the podetia..... 25a. *C. verticillata cervicornis*.

Cortex continuous to scattered, areolate.

Podetia sorediate between the scattered areoles.

Podetia sometimes squamulose toward the base, commonly cup-bearing..... 23. *C. gracilis*.Podetia squamulose throughout; cups more irregular..... 23a. *C. gracilis dilacerata*.Podetia subtomentose between the scattered areoles, middle-sized, cylindrical or turbinate, sometimes squamulose and often cup-bearing..... 24. *C. degenerans* and two subspecies, a and b.

Podetia not always corticate.

Podetia frequently becoming partly or almost wholly decorticate.

Podetia plainly squamulose.

Squamules small..... 15. *C. squamosa*.Squamules larger..... 15b. *C. squamosa phyllocoma*.

Podetia not plainly squamulose.

Podetia almost destitute of squamules..... 15a. *C. squamosa multibracteata*.Podetia squamulose-scaly..... 14. *C. subsquamosa*.

- Podetia always partly or wholly decorticate.
- Tips of podetia often perforate when not cup-bearing.... 18. *C. cenotea*.
- Tips of podetia not perforate.
- Podetia not cup-bearing.
- Podetia variously decorticate and soresiate..... 22. *C. decorticata*.
- Podetia wholly decorticate and soresiate, or corticate toward the base..... 27e. *C. fimbriata subulata*.
- Podetia frequently cup-bearing..... 27. *C. fimbriata* and subspecies below.
- Podetia short; cups common..... 27a. *C. fimbriata simplex*.
- Podetia longer.
- Cups common and well developed.
- Cups copiously and repeatedly proliferate..... 27b. *C. fimbriata proliferata*.
- Cups not so copiously proliferate..... 27d. *C. fimbriata radiata*.
- Cups absent or poorly developed.
- Podetia much elongated..... 27c. *C. fimbriata cornutoradiata*.
- Podetia not so much elongated.
- Podetia still quite long..... 27f. *C. fimbriata nemoxyna*.
- Podetia shorter.
- Podetia quite stout and not often squamulose..... 27g. *C. fimbriata coniocraea*.
- Podetia more slender and more frequently squamulose..... 27h. *C. fimbriata apoplepta*.
- Podetia shorter.
- Podetia very short.
- Podetia abortive, decorticate..... 16. *C. caespiticia*.
- Podetia always evident, partly decorticate..... 17. *C. delicata*.
- Podetia somewhat longer.
- Podetia not cup-bearing.
- Podetia corticate throughout.
- Podetia simple or branched toward the apex..... 20. *C. mitrula*.
- Podetia freely branching, often from the base..... 21. *C. cariosa*.
- Podetia decorticate, at least toward the top..... 28a. *C. pityrea subacuta*.
- Podetia cup-bearing, at least sometimes.
- Cups not very commonly present.
- Cups rarely and abortively present..... 29. *C. botrytes*.
- Cups more often present..... 28. *C. pityrea*.
- Cups always present.
- Squamules of the primary thallus thinner and more incised.
- Podetia corticate throughout..... 26. *C. pyxidata*.
- Podetia decorticate above..... 26a. *C. pyxidata chlorophaea*.
- Squamules of the primary thallus thicker and less incised, closely packed into a brownish or olivaceous crust..... 26b. *C. pyxidata pocillum*.



CLADONIA RANGIFERINA (L.) WEB. (REINDEER MOSS.)

1. *Cladonia rangiferina* (L.) Web. in Wig. Prim. Fl. Hols. 90. 1780. PLATE 12.

Lichen rangiferinus L. Sp. Pl. 1153. 1753.

Primary thallus rarely seen, when present crustose and delicate and composed of subglobose, depressed or irregular, clustered or scattered verrucæ, these 0.25 to 0.4 mm. in diameter, ashy-white and destitute of cortical layer; podetia arising from the surface of the verrucæ, often as branches of old or dying podetia or from free fragments of old podetia, dying at the base, 3 to 20 cm. long and 0.7 to 3 mm. in diameter, subcylindrical and cupless, subdichotomously or subradiately branched, the short branches usually unilaterally deflexed and their axils somewhat dilated or frequently perforate, the apices subulate or furcellate, clustered or subsolitary among other lichens and mosses, erect or rarely ascending or even decumbent, the sterile apices commonly nutant and often brownish, the remainder of the podetium sea-green, varying toward gray or grayish brown; apothecia small, 0.5 to 2 mm. in diameter, solitary or clustered at the apices of the branches, immarginate, convex, commonly brown; hypothecium pale or the subhymenial portion brownish; hymenium brownish, or pale below; paraphyses frequently somewhat gelatinized, usually simple, the apex commonly somewhat thickened and brownish; asci cylindrico-clavate.

Generally distributed over the State, but common only in the northern part, where it reaches its largest size. The largest of our *Cladonias* and one of our most beautiful lichens. On earth, which frequently consists only of a thin layer of humus over rocks, or in crevices between rocks; also on old wood in a more or less depauperate condition. Especially common under pines or other conifers.

Widely distributed in North America. Quite general also in its foreign distribution.^a

EXPLANATION OF PLATE 12.—Plant on earth, portion of a cluster 45 cm. broad. One-fourth natural size.

2. *Cladonia sylvatica* (L.) Hoffm. Deutsch. Fl. 114. 1795.

Lichen sylvaticus L. Sp. Pl. 1153. 1753.

Primary thallus rarely seen, when present crustose, delicate, and composed of subglobose clustered or scattered verrucæ, these 0.12 to 0.48 mm. in diameter, straw gold-colored, destitute of a cortical layer; podetia without cortex, commonly formed from branches of old or dying podetia or rarely arising from verrucæ of the primary thallus, dying at the base, 3 to 15 cm. long and 0.5 to 3 or 4 mm. in diameter, cylindrical or subcylindrical, cupless, often somewhat dilated in the axils, dichotomously or finally sympodially or radiately branched, one or two radii becoming large and erect, the others remaining short and usually unilaterally or irregularly fasciculate and deflexed, the upper branches not much shortened and forming loose clusters, the apices subulate and very minutely radiate or furcate-spinose, the upper ones especially often brownish or brown; growing in clusters or subsolitary among other lichens and mosses, erect or rarely ascending or decumbent, the upper sterile apices often more or less nutant, the axils frequently perforated, often minutely webby tomentose, whitish or yellowish straw-colored or sea-green; apothecia small, 0.5 to 1.2 mm. in diameter, corymbose, solitary or clustered at the apices of the branches, having a thin margin or immarginate, convex or depressed-convex, brown or possibly varying toward brick red; hypothecium pale or the subhymenial portion brownish; hymenium brown or brownish above and brownish or pale below; paraphyses usually simple, commonly thickened and brownish toward the apex; asci clavate.

Occurs with the last and frequently mixed with it in the same clusters; even more rare in the southern portion of the State. Clusters frequently as large as those of the last.

American and foreign distribution quite as general as that of the last.

^a This is the "reindeer moss." For economic use see p. 34.

3. *Cladonia alpestris* (L.) Rabenh. Clad. Eur. Exsicc. *pl. 39. no. 11.* 1860.

FRONTISPIECE. PLATE 13.

Lichen rangiferinus alpestris L. Sp. Pl. 1153. 1753.

Primary thallus rarely present, crustose, delicate, consisting of subglobose or irregular, clustered or scattered verrucæ, these 0.16 to 0.30 mm. in diameter, straw-colored and destitute of a cortical layer; podetia arising from the verrucæ of the primary thallus, often springing from old or dying podetia or from free fragments of dying podetia, dying away at the base, 5 to 20 cm. long and 0.5 to 2.5 mm. in diameter, subcylindrical, often somewhat dilated in the axils, cupless, rarely somewhat subdichotomously or more commonly radiately or fasciculately branched, frequently with 4 to 6 branches surrounding a perforation in the axil, one branch or often more becoming larger and erect, the others remaining shorter and becoming finally unilaterally fasciculate and deflexed, the upper branches shortened, forming dense thyrses, the apices subulate or slightly radiately spinose; for the most part straight, clustered, erect, ecorticate, whitish or yellowish straw-colored, the apices often brighter; apothecia small, 0.3 to 0.5 mm. in diameter, disposed in dense corymbs at the apices of the branches, solitary, clustered, or confluent, thinly margined or immarginate, usually convex, light or darker brown; hypothecium pale; hymenium brownish above and pale or pale brownish below; paraphyses simple or rarely branched, commonly enlarged and brownish toward the apex; asci clavate to cylindrico-clavate.

Occurs with the last two species and frequently in the same cluster with one or both of them; more beautiful than either in its color, in the delicacy of its branching, and in the arrangement of its clusters. Quite common in the northern portion of the State, but not known to exist in the southern half.

American and foreign distribution quite similar to that of the last two, but though all three prefer cold regions, this species is more nearly confined to such territory than either of the others.

EXPLANATION OF FRONTISPIECE.—Plant on earth in woods. From a specimen found at Grand Portage, Minn. One-fourth natural size.

EXPLANATION OF PLATE 13.—Plant on earth, part of a cluster 60 cm. broad. Natural size.

4. *Cladonia bacillaris* (Del.) Nyl. Lich. Lapp. Or. 179. 1866.

PLATE 14, A.

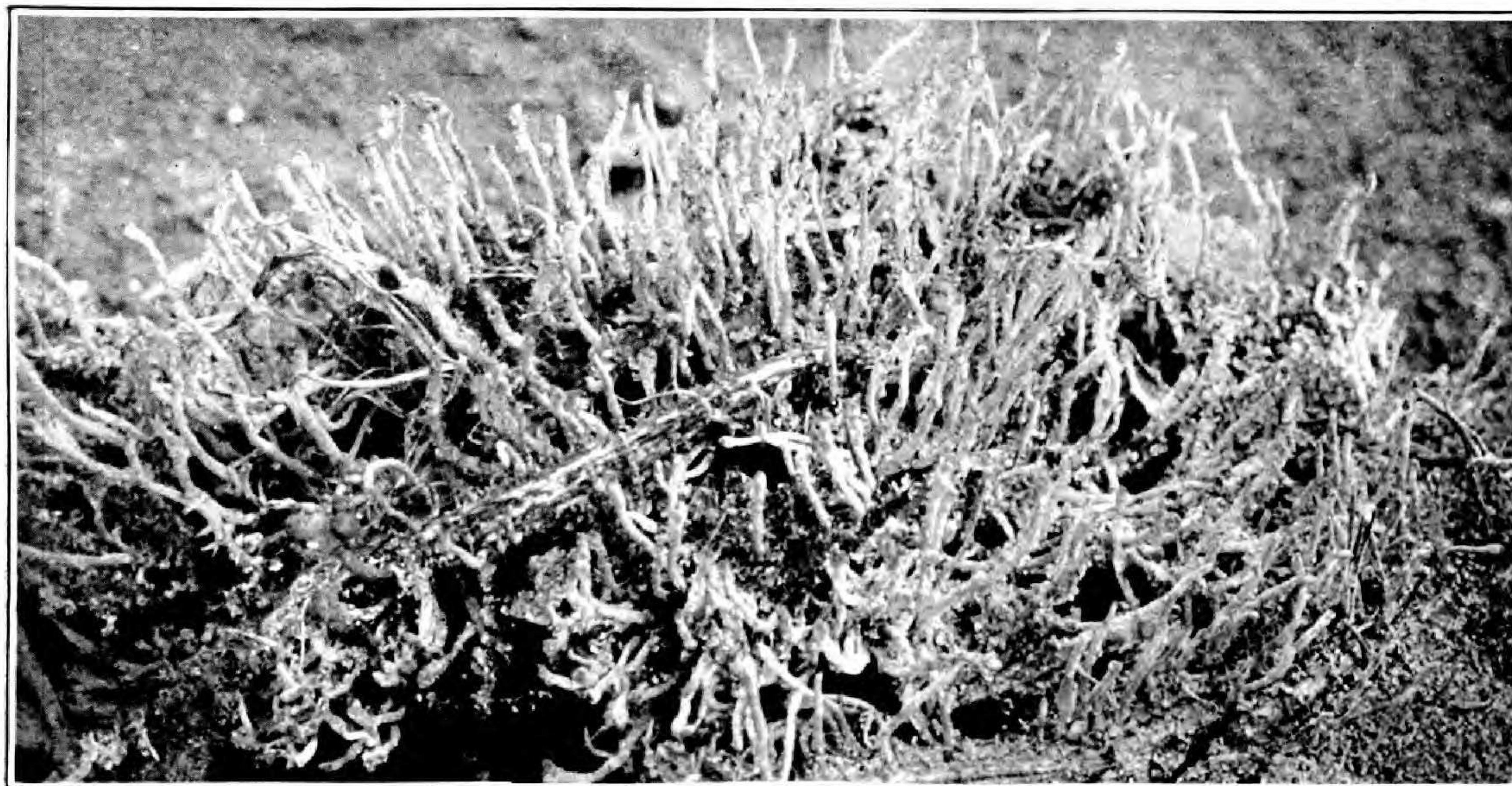
Cenomyce bacillaris Del. in DC. Bot. Gall. ed. 2. 2: 634. 1830.

Primary thallus persistent or finally dying, composed of laciniate, lobate, or crenate squamules, which are 1 to 3 mm. long, flat or somewhat involute, scattered or clustered, sea-green or varying toward whitish or olivaceous above and wholly white below or darker toward the base of the squamule, sometimes sorediate along the margin and below; podetia arising from the surface of the squamules, quite slender, subcylindrical, rarely enlarged toward the apex, 5 to 55 mm. long and 0.5 to 2 mm. in diameter, or even 4 mm. at the apex, cupless or rarely very imperfectly scyphiform, simple or rarely branched, often sterile and the apex obtuse or rarely subulate, or terminated by imperforate, clustered or solitary apothecia; erect, for the greater part or entirely sorediate, sometimes squamulose toward the base, and the squamules frequently occurring half way up or rarely even to the top, often corticate toward the base and below the apothecia, ashy, sea-green, or olivaceous, or a mixture of these colors; apothecia medium-sized, 1 to 5 mm. in diameter, solitary or clustered, immarginate or rarely thinly margined, usually convex, scarlet; hypothecium pale; hymenium reddish toward the top and paler toward the lower part; paraphyses simple or branched toward the thickened and reddish apex; asci cylindrico-clavate; spores obliquely disposed.

Usually growing on old logs or stumps, though also occurring on earth. Doubtless occurs in all portions of the State, but has been confused with the next, from which it is not easily distinguished.



CLADONIA ALPESTRIS (L.) RABENH.



A. CLADONIA BACILLARIS (DEL.) NYL.



B. CLADONIA FIMBRIATA CONIOCRAEA (FLOERKE) WAINIO.

Little is known of its North American distribution owing to the confusion just mentioned. Known also in Europe and Africa.

EXPLANATION OF PLATE 14.—A, Plant of *Cladonia bacillaris* on humus over rocks, showing the primary thallus and the podetia. B, Plant of *C. fimbriata coniocraea* on earth in pine woods, showing the cupless podetia. A natural size; B enlarged 2 diameters.

5. *Cladonia macilenta* Hoffm. Deutsch. Fl. 2: 126. 1795.

Primary thallus persistent or finally dying, composed of laciniate, lobate-laciniate, crenate, or rarely subentire, small or medium-sized squamules, these 1 to 4 mm. long and 1 to 3 mm. wide, flat or somewhat involute, scattered or clustered, sea-green, whitish sea-green, or olivaceous above, white below or darker or rarely yellow toward the base of the squamules, the margin and lower side sometimes sorediate; podetia arising from the surface of the primary thallus, short or elongated, rather slender, subcylindrical or clavate, 0.5 to 4.5 cm. long and 0.5 to 2 mm. in diameter, cupless, simple or branched, the apices obtuse or impressed, sterile or terminated by imperforate, clustered or scattered apothecia, erect, squamulose, squamulose toward the base, or rarely entirely squamulose, often corticate toward the base and below the apothecia, white or sea-green; apothecia small or more commonly middle-sized, 0.5 to 2.5 mm. in diameter, solitary or somewhat densely clustered, convex, immarginate or having a thin margin, scarlet; hypothecium pale; hymenium red above and pale yellowish below; paraphyses usually simple, more or less thickened at the pale or reddish apex; asci clavate or cylindrico-clavate; spores irregularly arranged.

The plant surely occurs in northern Minnesota, but Doctor Wainio has referred nearly all of our material, placed here in the preliminary reports, to the last preceding species. The two species are by no means clearly distinct, but the present plant is likely to be larger and to have branched podetia. The spore arrangement is not easy to make out and can not always be depended upon.

The species is known in all continents, and, according to Tuckerman's view, is widely distributed in North America. However, many of the specimens referred to here by him will doubtless have to be placed eventually with the last foregoing.

6. *Cladonia digitata* Hoffm. Deutsch. Fl. 2: 124. 1795.

Primary thallus persistent or finally dying, composed of lobed or incised, large or medium-sized squamules, which are 2 to 15 mm. long and wide, involute or somewhat flat, scattered or clustered, sea-green or rarely olivaceous above, white below or dull or yellowish toward the base, sometimes sorediate at the margins and below; podetia arising from the surface of the primary thallus, rather short but well developed, 1 to 5 cm. long, the lower part 0.5 to 4 mm. in diameter and cylindrical or often incrassate below the cups, rarely cupless; erect or decumbent, simple or repeatedly proliferous, the upper part and especially the cups sorediate or the cavity of the cups often corticate, the lower part or sometimes the whole podetium covered with a continuous cortex, without squamules or more or less squamulose, whitish or yellowish sea-green; cups medium-sized, 3 to 10 mm. in diameter, 2 to 5 mm. high, commonly abruptly dilated, regular or irregular, the margin commonly somewhat incurved, subentire, dentate, radiate or proliferate, imperforate; apothecia medium-sized, large or rarely small, 0.5 to 5 mm. in diameter, placed at the apices of the branches or rarely on the margin of the cups, single or clustered, convex and immarginate, scarlet; hypothecium pale; hymenium scarlet above, pale red below; paraphyses simple or rarely branched, somewhat enlarged toward the apex; asci cylindrico-clavate.

A rare lichen in Minnesota, thus far found only in four or five localities in the pineries of the northern half of the State. Grows on old logs and stumps.

The plant occurs in all continents, but seems to be more common north than south of the equator and in arctic and subarctic regions. In North America confined to the northern United States and British America and mountainous regions farther south.

7. *Cladonia coccifera* (L.) Willd. Fl. Berol. Prodr. 361. 1787.*Lichen cocciferus* L. Sp. Pl. 1151. 1753.

Primary thallus usually persistent, composed of irregularly or flabellately incised, crenate or lobate, small or larger squamules, which are 1 to 4 mm. long and 1 to 3 mm. wide (foreign measurements more than twice as large), flat or somewhat involute, the lower side often more or less distinctly nervose, clustered or scattered, light to reddish sea-green above and white below or yellowish toward the base, the base and the nerves yellow or red, rarely sorediate above and at the margins; podetia arising from the surface of the primary thallus, 4 to 50 mm. long and 1 to 4 mm. in diameter at the base, cup-bearing, cylindrical or turbinate, erect, corticate, sea-green, frequently yellowish or reddish-tinged, the cortex subcontinuous or areolate, in the latter case the decorticate areas between the areoles frequently white or yellowish, rarely more or less squamulose; cups gradually or abruptly dilated, sometimes becoming oblique, subentire, dentate, radiate or proliferate, 1 to 4 proliferations from a cup, themselves bearing cups or apothecia; proliferations arising from the margins of the cups or rarely from within, the lower rank 4 to 30 mm. long, the upper one or more ranks usually shorter; apothecia varying much in size, 1 to 8 mm. in diameter in ours (frequently twice as large in foreign specimens), clustered or solitary, at the dilated apices of the proliferations or sessile on the margins of the cups, convex or depressed-convex, thinly margined or more commonly immarginate, scarlet in ours; hypothecium pale; hymenium pale red above and pale below; paraphyses usually simple, somewhat enlarged at the apex; asci cylindrico-clavate.

The plant grows on earth, especially humus over rocks, and on old wood. In northern Minnesota, north and west of Duluth. Tuckerman gives the species as distributed throughout the Northern States and British America and southward in the mountains. He uses the synonym *Cladonia cornucopioides*.

The species is quite cosmopolitan in distribution, extending into temperate regions in mountains. Probably absent from Africa.

7a. *Cladonia coccifera pleurota* (Floerke) Schaer. Lich. Helv. Spic. 1: 24. 1823.*Capitularia pleurota* Floerke, Ges. Nat. Freund. Mag. 2: 218. 1808.

Podetia corticate below but more or less decorticated and sorediate above; squamules usually sorediate below and along the margin; apothecia said to be sometimes marginate. The squamules seem to be somewhat smaller in this subspecies, and the apothecia frequently somewhat stipitate.

Occurs with the last, but is less common in the State, thus far only four times noted.

American and foreign distribution about the same as that of the species.

8. *Cladonia deformis* (L.) Hoffm. Deutsch. Fl. 2: 120. 1795.

PLATE 15.

Lichen deformis L. Sp. Pl. 1152. 1753.

Primary thallus usually dying away, when present composed of incised, crenate or lobed, usually medium-sized squamules, these 2 to 7 mm. long and wide, ascending or depressed, flat or somewhat involute or convex, sometimes lacunose, scattered or clustered, sea-green, varying toward lighter or reddish, or even light red toward the base, below pale or brownish and sometimes sorediate; podetia arising from the surface of the primary thallus, 25 to 85 mm. in length, subcylindrical or rarely elongate-turbinate, scyphiform or rarely cupless, erect, partly and uniformly sorediate, the lower portion corticate, the cortex continuous and lacunose, or else rimose, the lower portion sometimes squamulose, the corticate portion yellow straw-colored to sea-green, the sorediate part sulphureous or straw-yellow; cups gradually or abruptly dilated, imperforate, medium-sized or small, 3 to 10 mm. in diameter, the margin subentire, dentate or often irregularly lacerate or proliferate, the proliferations solitary or numerous, their apices minutely scyphiform or obtuse, in 1 to 3 ranks, the lower rank long, the upper ranks and proliferations short, the cavity of the cups



CLADONIA DEFORMIS (L.) HOFFM.

usually minutely farinose; apothecia usually medium-sized, 0.5 to 5 mm. in diameter, scattered on the margins of the cups or clustered at the dilated apices of the proliferations, convex or depressed, commonly having a thin margin, scarlet; hypothecium pale; hymenium pale below and pale scarlet above; paraphyses sometimes branched, not often enlarged or colored toward the apex (?); asci cylindrico-clavate.

More or less frequent in the northern portion of the State. On earth or rarely on old wood. Ours uniformly sterile and the cups usually without proliferations, thus the plants single-ranked.

Distributed throughout the extreme northern portion of United States and through British America and farther south in the mountains. Known also in all of the grand divisions.

EXPLANATION OF PLATE 15.—Plant of *Cladonia deformis* at base of an old stump, showing the primary thallus and the podetia, some of the latter cup-bearing. Natural size.

9. *Cladonia cristatella* Tuck. Amer. Journ. Sci. **25**: 428. 1858.

Primary thallus usually persistent, composed of incised or crenate, small squamules, these 2 to 3 mm. long and wide, commonly flat but sometimes involute, scattered or clustered, sea-green or straw-yellow above and whitish below, sometimes sorediate above; podetia arising from the surface of the squamules, usually of moderate length, 4 to 35 mm. long and 0.5 to 2.5 mm. wide, subcylindrical or somewhat enlarged toward the apex, without cups, simple or more or less fasciculately or digitately branched toward the apex, the branches short and obtuse, the apex or apices commonly terminated by apothecia, the axils sometimes perforate; clustered or subsolitary, erect, rarely squamulose, the cortex continuous or areolate, smooth or roughened, sea-green or straw-yellow; apothecia medium-sized or small, 0.3 to 3 mm. in diameter, solitary or clustered, convex, immarginate, scarlet; hypothecium pale or pale yellowish; hymenium pale reddish above and pale or pale yellowish below; paraphyses commonly simple, the apices only slightly thickened or colored; asci cylindrico-clavate.

Generally distributed over the State. On old wood and earth, especially common in recently burned forest regions in the northern portion of the State.

Distributed throughout the United States east of the Rocky Mountains and at least as far north in British America as Newfoundland. A North American plant.

9a. *Cladonia cristatella vestita* Tuck. Syn. N. A. Lich. **1**: 255. 1882.

A form with densely squamulose podetia.

A plant collected at Tower, in the northern part of the State, was referred here by Doctor Wainio. On rocks.

Elsewhere reported from Massachusetts and New Jersey.

9b. *Cladonia cristatella paludicola* Tuck. Syn. N. A. Lich. **1**: 255. 1882.

Squamules sorediate and the podetia short or wanting.

A single specimen is recorded from Mankato. On an old log. The squamules are scarcely sorediate and the determination may be regarded as doubtful.

Indefinitely reported from swamps by Tuckerman.

10. *Cladonia amaurocraea* (Floerke) Schaer. Lich. Helv. Spic. **1**: 34. 1823.

Capitularia amaurocraea Floerke in Web. & Mohr, Beitr. Naturk. **2**: 334. 1810.

Primary thallus rarely seen, when present composed of small crenate or digitately incised squamules, these 0.5 to 1.7 mm. long and wide, clustered or scattered, ascending or flat, sea-green above and white below; podetia formed from branches or free fragments of dying podetia, or rarely arising from the surface of the primary thallus, dying away at the base, 15 to 120 mm. long, 0.7 to 1.5 mm. in diameter, cupless and subcylindrical or sometimes cup-bearing, dichotomously or radiately or even irregularly branched, the axils closed or perforate, the branches divaricate, forming large

or small clusters, erect, ascending, or prostrate, the cortex continuous or areolate and frequently scattered, smooth or the areoles somewhat elevated, rarely somewhat squamulose toward the base, straw gold-colored or sea-green, or the decorticate portions rarely white, the basal dead portions frequently scarlet or darker, the apices straight, usually brownish, tapering and subulate, subsimple or dichotomously spinose or rarely cymosely branched, or rather rarely terminated by cups; cups commonly abruptly dilated and sometimes perforate or cribose, regular or oblique, the margin frequently spinulose and radiately lacerate and proliferous; apothecia medium-sized, 0.7 to 3.5 mm. in diameter, solitary or clustered at the apices of the podetia, thinly margined or immarginate, flat or convex, sometimes perforate, rarely lobate, brown or varying toward brick-red or lighter; hypothecium pale or pale yellowish; hymenium brownish above and pale or pale brownish below; paraphyses simple or branched toward the apex, usually enlarged and brownish; asci cylindrico-clavate.

Distributed throughout the northern portion of the State, especially to the northeast. On earth and rocks covered with humus.

Throughout the extreme northern portion of the United States, north to arctic America and also southward in the mountains. Known throughout the grand divisions.

11. *Cladonia uncialis* (L.) Hoffm. Deutsch. Fl. 2: 117. 1795.

Lichen uncialis L. Sp. Pl. 1153. 1753.

Primary thallus rarely present, composed of small crenate or incised, ascending or flat squamules, these scattered or clustered, sea-green to gold-colored above and white below, with a continuous cortex, small, 0.5 to 1 mm. long and wide; podetia formed from branches or fragments of dying podetia, or rarely arising from the margins of the squamules, dying at the base, 20 to 75 mm. long, 1 to 3 mm. in diameter, subcylindrical, usually cupless, but the apices frequently dilated and somewhat scyphiform, dichotomously, sympodially, or radiately branched, the radii 3 to 5 or more, all well developed or some shorter, the axils for the most part perforate, the cortex subcontinuous or often areolate and scattered, smooth or the areoles more or less raised, destitute of squamules, straw-colored or rarely sea-green, or the decorticate portions whitish, the apices straight, subulate or radiately or furcately spinose, rarely brown; apothecia small, 0.5 to 0.8 mm. in diameter, at the apices of short branches, solitary or clustered, immarginate or thinly margined, flat or convex, brown varying toward brick red; hypothecium usually pale; hymenium brownish above and usually pale below; paraphyses simple or rarely branched, commonly enlarged and brownish toward the apex; asci clavate.

Generally distributed throughout the northern portion of the State. On earth, usually over rocks.

Common throughout North America and cosmopolitan also in its foreign distribution.

11a. *Cladonia uncialis obtusata* (Ach.) Schaer. Enum. Crit. Lich. Eur. 200. 1850.

Cenomyce uncialis obtusata Ach. Lich. Univ. 559. 1810.

Thallus differing in that the apices of the branches are short and obtuse.

The axils are said to be minutely perforate, in which respect our specimen, determined by Doctor Wainio, hardly agrees.

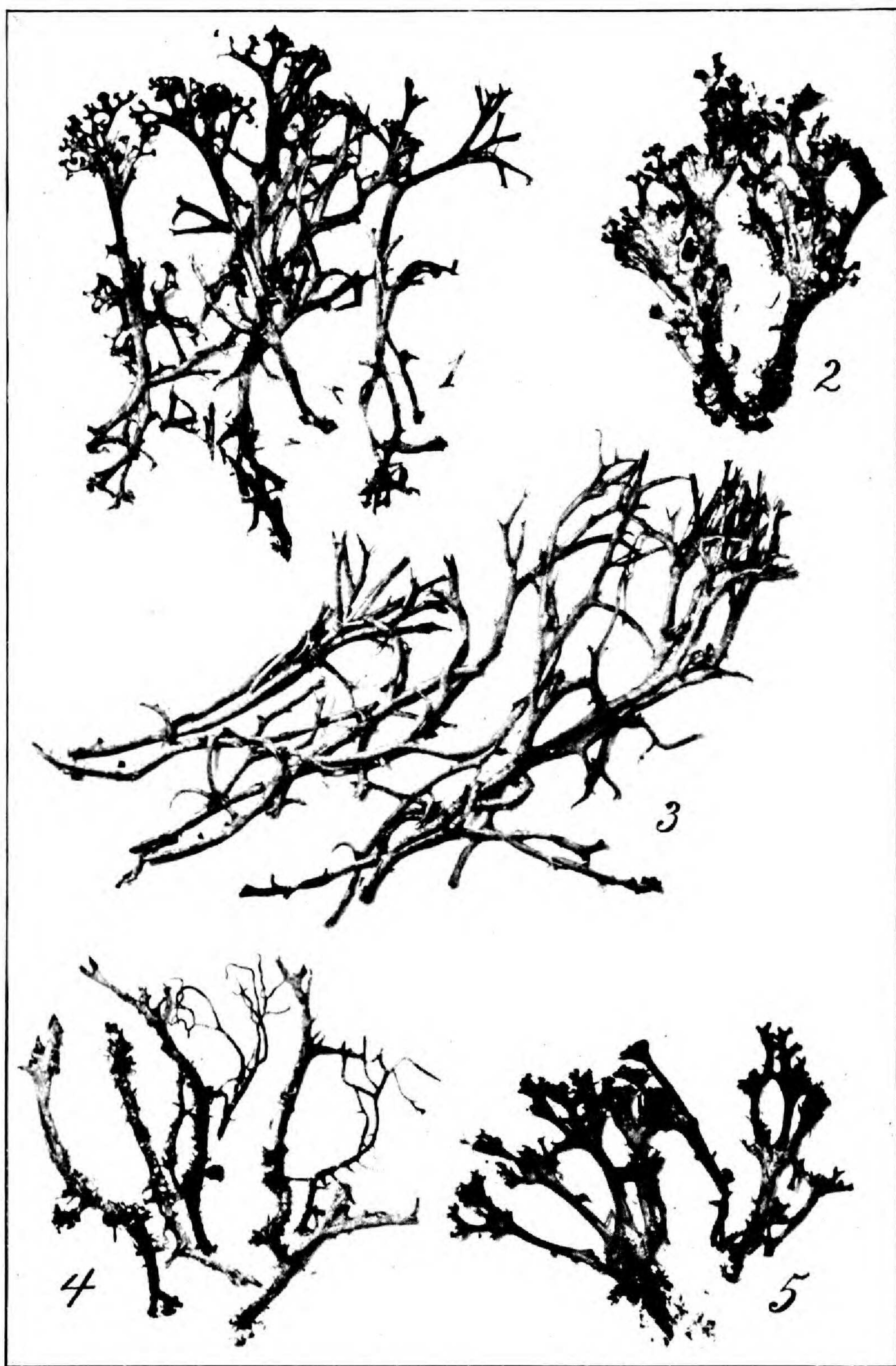
A single collection was made on Blueberry Island in Lake of the Woods. On earth.

No other record of it in North America has been found. Well known in Europe.

12. *Cladonia furcata* (Huds.) Schrad. Spic. Fl. Germ. 107. 1794.

Lichen furcatus Huds. Fl. Angl. 458. 1762.

Primary thallus usually disappearing, when present composed of medium-sized squamules, these crenately or irregularly lobed or rarely subentire, 2 to 5 mm. long and wide, ascending or flat, scattered or clustered, sea-green varying to



SUBSPECIES OF CLADONIA FURCATA (HUDS.) SCHRAD.

brownish or whitish above, white below, the cortical layer continuous; podetia arising from the surface of the squamules, the lower part dying away, 15 to 85 mm. long and 0.7 to 2 mm. in diameter, cylindrical or subcylindrical, very rarely scyphiform, dichotomously or frequently radiately branched, erect or rarely prostrate or decumbent, rarely somewhat sorediate, the cortex continuous or more or less dispersed, smooth or rarely subrugose, sometimes squamulose, sea-green varying toward whitish or brownish, the branches suberect, divaricate or recurved, the axils somewhat dilated and frequently perforate, the apices suberect or recurved, slender and delicate; apothecia small, 0.5 to 1.5 mm. in diameter, irregularly or cymosely disposed at the apices of the branches, immarginate, sometimes lobate or reniform, convex, rarely perforate at the center; brown varying toward brick red or lighter color; hypothecium pale; hymenium brownish above and pale below; paraphyses simple or rarely branched, frequently enlarged and brownish toward the apex; asci cylindrico-clavate.

Generally distributed over the State in one form or another. On earth, frequently over rocks, or rarely on old wood.

Generally distributed over North America. Cosmopolitan also in its foreign distribution.

12a. *Cladonia furcata scabriuscula* (Del.) Wainio, Act. Soc. Faun. Flor. Fenn. 4: 338. 1887. PLATE 16, FIGURE 4.

Cenomyce scabriuscula Del. in DC. Bot. Gall. ed. 2. 623. 1830.

Podetia more or less isidioid or sorediate, sometimes squamulose, the cortex more or less broken, partly wanting toward the top, whitish.

Frequent in the northern portion of the State and once collected as far south as Redwood Falls. Habitat as above.

Common in Europe and known also in South America and Australia. Thus far recorded elsewhere in North America only from Iowa, Canada, Newfoundland, and Massachusetts (New Bedford).

EXPLANATION OF PLATE 16.—Subspecies of *Cladonia furcata*. Fig. 1, *C. furcata racemosa*. Fig. 2, *C. furcata finkii*. Fig. 3, *C. furcata pinnata*. Fig. 4, *C. furcata scabriuscula*. Fig. 5, *C. furcata paradoxa*. Figs. 1-5, natural size.

12b. *Cladonia furcata paradoxa* (Wainio) Fink, Minn. Bot. Stud. 3: 217. 1903.

PLATE 16, FIGURE 5.

Cladonia furcata palamaea paradoxa Wainio, Act. Soc. Faun. Flor. Fenn. 4: 349. 1887.

Podetia 10 to 20 mm. long and 0.7 to 1 mm. in diameter, bearing cups 2 to 3 mm. in diameter and quite abruptly dilated, brownish or olive-brown or sea-green toward the base, there sometimes squamulose; cups irregularly proliferate, perforate, or subcribrose, the proliferations cup-bearing and forming two or three ranks; apothecia seldom clustered, often perforate or lobate, brown, convex, immarginate, quite common in ours.

Frequent throughout the northern portion of the State. On old wood and earth.

Not known in America outside of Minnesota. Previously known in Europe.

12c. *Cladonia furcata finkii* Wainio, Minn. Bot. Stud. 3: 217. 1903.

PLATE 16, FIGURE 2.

Podetia rather stout, 15 to 75 mm. long and 1 to 3 mm. in diameter, scyphiform and frequently 2 or 3-ranked, the cortex subcontinuous, usually more or less squamose even toward the top, whitish sea-green or slightly olivaceous, the ultimate branchlets sometimes quite similar to those of subspecies *racemosa* (pl. 16, fig. 1), but more irregular, quite commonly fruited; cups irregular and sometimes perforate, those of the upper ranks not often developed.

Wainio writes, "Scyphifera et analogae f. *paradoxae*, in quam transit, et e var. *racemosa* est evoluta, et in colore congruens."

Collected in several localities in northern Minnesota, along Rainy River and Rainy Lake; also on islands in Lake of the Woods. On earth, and on decaying wood on the ground.

Not known elsewhere.

12d. *Cladonia furcata pinnata* (Floerke) Wainio, Act. Soc. Faun. Flor. Fenn. 4: 332. 1887. PLATE 16, FIGURE 3.

Cenomyce racemosa pinnata Floerke in Schleich. Cat. Pl. Helv. 47. 1821.

Podetia squamulose, the squamules incised or lobate-crenate, commonly smoothish; cortex subcontinuous or areolate, or rarely in part wanting; usually sea-green or whitish; apothecia subentire.

Collected at Gunflint and in the Misquah Hills, both in the northern portion of the State.

Wainio records the subspecies from Mexico, South Carolina, Vancouver Island, New York, and from various parts of British America. It was doubtless included in Tuckerman's conception of *C. furcata racemosa* (Hoffm.) Floerke^a, which may also occur in Minnesota. Reported from all of the grand divisions except Africa.

13. *Cladonia crispata* (Ach.) Flot. in Wendt. Therm. Warmbr. 96. 1839.

Baeomyces turbinatus crispatus Ach. Meth. Lich. 341. 1803.

Primary thallus persistent or finally dying, composed of medium-sized digitate-lacinate or crenate squamules, which are 1 to 4 mm. long and wide, ascending, flat or involute, scattered or rarely clustered and forming a compact crust, in color light or darker sea-green or even olive-brown above, below white or brownish or reddish toward the base, the cortex continuous; podetia arising from the surface of the primary thallus, the base sometimes dying away, 1 to 7.5 or possibly 10 cm. in length and 0.5 to 5 mm. in diameter, subcylindrical or irregularly turgescient, radially or sympodially branched, the branches suberect or spreading, the axils commonly somewhat dilate-open, the cortex subcontinuous or dispersed-areolate, the areoles frequently more or less raised, sometimes more or less squamulose; sea-green or variously whitish, reddish, brownish, or olivaceous, most commonly scyphiform; cups abruptly dilated and frequently perforate, borne at the apices of the branches, repeatedly proliferate at the margin; apothecia small, 0.5 to 0.7 mm. in diameter, at the apices of the short branches or at the ends of the proliferations of the cups, subsolitary or subcorymbosely aggregated, immarginate or with thin margin, flat or convex, brown or rarely brick red; hypothecium pale; hymenium pale or pale brownish below and brownish above; paraphyses commonly simple, thickened but usually pale at the apex; asci cylindrico-clavate.

Collected at several places in the northern part of the State. On earth and old wood.

Found in Massachusetts, Wisconsin, and California, and northward in British America and Alaska. Known also in South America, Europe, and Asia.

14. *Cladonia subsquamosa* (Nyl.) Wainio, Acta Soc. Faun. Flor. Fenn. 4: 445. 1887.

Cladonia delicata subsquamosa Nyl. Ann. Mag. Nat. Hist. III. 18: 407. 1866.

Primary thallus composed of middle-sized squamules, these commonly disappearing sooner or later; podetia arising from the surface of the squamules, 12 to 35 mm. long in ours and becoming twice as long in foreign plants, subcylindrical or tubæform, sometimes scyphiform, irregularly branched or rarely simple, the axils sometimes perforate, the apices scyphiform, obtuse, perforate or rarely subulate, erect, the cortex verrucose or areolate or almost wholly wanting; sometimes squamulose toward the base, and squamulose-scaly higher up, whitish sea-green or varying toward brownish, the base sometimes dying and becoming dark-colored; cups when present perforate, and the margin becoming repeatedly proliferate; apothecia commonly small,

^a Clad. Comm. 152. 1828.

0.5 to 0.7 mm. in diameter, subsolitary or more or less aggregated at the apices of the branches, flat and thinly margined or becoming convex and immarginate, brown; hypothecium pale; hymenium pale below and brownish above; paraphyses with thickened apices; asci clavate.

Our plant is sterile, and the apothecial characters are taken from Wainio.

A single collection from Emo was placed here by Doctor Wainio. On earth over rocks.

Previously known in North America only from Vancouver Island, Puget Sound, and Alaska. A rare plant, Wainio citing a single station each for Europe, South America, and Australia.

15. *Cladonia squamosa* (Scop.) Hoffm. Deutsch. Fl. 2: 125. 1795.

Lichen squamosus Scop. Fl. Carn. ed. 2. 2: 368. 1772.

Primary thallus commonly persistent, composed of middle-sized or rarely large, crenate, irregularly subdigitate or subpinnate-lacinate squamules, these 1.5 to 7 mm. long and 1 to 5 mm. wide, ascending, flat or involute, scattered or clustered and rarely cespitosé so as to form a compact crust, sea-green varying toward ashy or brown above, below white, the cortex continuous; podetia arising from the surface of the primary thallus, rarely dying at the base, 10 to 85 mm. long and 2 to 5 mm. in diameter, subcylindrical or rarely trumpet-shaped, irregularly turgescient, clustered, erect, ascending, decumbent or irregularly flexuous, rarely simple or commonly more or less irregularly or radiately branched, the branches erect or spreading, the axils frequently open, the cortex areolate, or subcontinuous toward the base, the areoles sometimes scattered or entirely disappearing above, the podetia soresiate above, the corticate portions commonly squamulose with frequently lacinate squamules, ashy, sea-green, olivaceous, or brown, or variegated with these colors, commonly scyphiform; cups abruptly dilated, medium-sized or small, usually perforate, the margin commonly repeatedly proliferate; apothecia small, 0.5 to 0.7 mm. in diameter, on the margin of the cups or at the ends of branches or proliferations, subsolitary or clustered, thinly margined or immarginate, flat or becoming convex, brown or rarely pale brown or possibly brick-red; hypothecium pale; hymenium pale or pale brownish below and commonly brownish above; paraphyses usually simple, sometimes thickened and brownish toward the apex; asci clavate or cylindrico-clavate.

Generally distributed over the State. On old wood and earth.

The plant is widely distributed in North America and is also quite cosmopolitan in its foreign distribution.

15a. *Cladonia squamosa multibrachiata* (Floerke) Wainio, Act. Soc. Faun. Flor. Fenn. 4: 437. 1887.

Cladonia squamosa asperella multibrachiata Floerke, Clad. Comm. 133. 1828.

Podetia scyphiform and almost destitute of squamules.

Ours, determined by Doctor Wainio, is a small plant, 10 to 25 mm. long and 1 to 2.5 mm. in diameter, with cups irregular and proliferate.

The plant determined by Doctor Wainio is from Rainy Lake City. Others from Gunflint and Snowbank Lake seem to be the same.

Not known elsewhere in North America. Otherwise confined to Europe.

15b. *Cladonia squamosa phyllocoma* (Rabenh.) Wainio, Act. Soc. Faun. Flor. Fenn. 4: 441. 1887.

Cladonia squamosa macrophylla phyllocoma Rabenh. Clad. Eur. Exsicc. pl. 26. no. 20. 1860.

Podetia scyphiform, corticate, more or less squamulose with rather large squamules.

A single collection from Emo on the international boundary has been placed here by Doctor Wainio. A European form not known elsewhere in North America.

16. *Cladonia caespiticia* (Pers.) Floerke, Clad. Comm. 8. 1828.

Baeomyces caespiticius Pers. Ann. Bot. Usteri 7:155. 1794.

Primary thallus persistent and composed of subdigitately laciniate, incised or crenate, ascending, flat or rarely involute squamules, these middle-sized, 2 to 10 mm. long and 1.5 to 8 mm. in width, commonly clustered and thus forming larger or smaller patches, sea-green varying toward whitish or olivaceous, the cortex continuous, frequently sorediate below, the color there white; podetia arising from the surface of the primary thallus, abortive or 1 to 5 mm. long and 0.4 to 1.5 mm. in diameter, subcylindrical or clavate, cupless, simple or rarely branched, the apices obtuse and always bearing apothecia; sometimes open at the apex, scattered, erect, decorticate, rarely squamulose, usually ashy in color; apothecia medium-sized or larger, 0.75 to 3 mm. in diameter, borne at the apices of podetia or rarely sessile, solitary or slightly clustered, thinly margined or immarginate, flat or convex, brown or reddish brown; hypothecium pale; hymenium pale below and pale or brownish above; paraphyses simple, the apices enlarged and pale or brownish; asci cylindrico-clavate.

Reported from widely separate portions of the State, but some of the material is doubtful. Certainly distributed widely in northern Minnesota, and doubtless to be found in all portions of the State. On rocks and old wood.

Distributed throughout the United States east of the Rocky Mountains and northward into British America. Also common in Europe, but scarcely extending into extreme arctic regions in either hemisphere.

17. *Cladonia delicata* (Ach.) Floerke, Clad. Comm. 7. 1828.

Lichen delicatus Ach. Lich. Suec. 199. 1798.

Primary thallus commonly persistent, composed of small laciniate, erose, or crenate squamules, these 1 to 2.5 mm. long and wide, ascending, flat or involute, commonly clustered and frequently forming a crust, ashy, sea-green or olivaceous above, below white and usually more or less sorediate, the cortex continuous above; podetia arising from the surface of the primary thallus, 3 to 10 mm. long and 0.5 to 1 mm. in diameter, cupless, subcylindrical, clavate or irregularly turgescens, usually simple or slightly branched at the apex, rarely quite freely branched lower down, the axils, the apices, and the sides sometimes more or less fissured; scattered or clustered, erect, commonly more or less sorediate and decorticate, and usually sorediate-furfuraceous, the apices usually apothecia-bearing and obtuse, but rarely sterile and subulate; apothecia small, 0.3 to 1.5 mm. in diameter, borne in clusters or solitary at the apices of the podetia or branches, thinly margined or immarginate, flat or convex, brown or rarely reddish brown; hypothecium pale or pale brownish; hymenium brownish and darker above; paraphyses simple or branched, the apices frequently thickened and pale brownish; asci clavate or cylindrico-clavate.

Collected at Taylors Falls, Beaver Bay, and Warroad. Thus widely distributed, but probably rare in the State. On old wood.

Distributed throughout the eastern half of the United States and northward into British America. Known in all the grand divisions.

18. *Cladonia cenotea* (Ach.) Schaer. Lich. Helv. Spic. 1: 35. 1823.

Baeomyces cenoteus Ach. Meth. Lich. 345. pl. 7. f. 7. 1803.

Primary thallus usually persistent, composed of middle-sized or small, irregularly divided, incised or subentire squamules, these 1 to 3 mm. long and wide, ascending, flat or involute, scattered or clustered, ashy, sea-green, brownish, or olivaceous above, the cortex continuous, beneath white and sometimes more or less sorediate; podetia arising from the surface of the primary thallus, 5 to 60 mm. long and 0.5 to 5 mm. in diameter (foreign specimens reaching 10 cm. long), subcylindrical, irregularly turgescens or trumpet-shaped, commonly erect, wholly decorticate and finely sorediate, or corticate toward the base, there also sometimes more or less squamulose, ashy, sea-green or

brownish or variegated with these colors, the apices scyphiform or cupless, in the latter case attenuate and perforate, rather rarely branched, the sides frequently perforate also, commonly more or less clustered; cups 2.5 to 8 mm. in diameter, perforate, commonly proliferate, the podetia thus becoming 2 or several-ranked; apothecia small, 0.5 to 1.5 mm. in diameter, borne on the margins of the cups or at the margins of branches or proliferations, subsolitary or more or less clustered, thinly margined or immarginate, flat or convex, brown or flesh-colored; hypothecium pale; hymenium usually pale brownish below and somewhat deeper brownish above; paraphyses simple or compound, the apex thickened and pale or brownish; asci clavate or cylindrico-clavate.

Distributed throughout the northern portion of the State. On old logs and on earth.

Found in the New England States; widely distributed throughout British America and in Alaska. Also reported from the Cascade Mountains. Known also in Europe, Asia, and Australia.

19. *Cladonia turgida* Hoffm. Deutsch. Fl. 2: 124. 1795.

Primary thallus commonly persistent, composed of large foliose laciniate or irregularly or subdichotomously lobed squamules, these 5 to 25 mm. long and 2 to 8 mm. wide, ascending or nearly erect, flat, convex and canaliculately revolute or even concave and involute, often cespitose in small or medium-sized clusters, ashy to sea-green above and white beneath, the cortex continuous; podetia arising from the surface of the primary thallus, one or more from a single squamule, the base sometimes dying away, 2 to 7 cm. long and 2 to 3 mm. in diameter, turbinate or subcylindrical and frequently turgescient, often more or less branched, the branches suberect, the axils frequently more or less open, scattered or cespitosely clustered, erect or ascending, areolate or with continuous cortex, sometimes more or less clothed with usually large squamules, light sea-green or the decorticate portions between the areoles white, the apices cupless, obtuse and bearing short branches, or imperfectly scyphiform, frequently olive-brown; cups somewhat dilate, shallow, perforate or cribose, radiately proliferate from the margin; apothecia small or medium-sized, 0.5 to 2 mm. in diameter, borne at the apices of the branches or proliferations, subcymosely or radiately arranged and frequently short-stipitate, thinly margined or convex and immarginate, brown or rarely reddish brown, often perforate; hypothecium pale; hymenium pale or pale brownish below and more brownish above; paraphyses simple or rarely branched, the apices usually thickened and brownish; asci cylindrical or cylindrico-clavate.

For the most part confined to the northern portion of the State, but once collected as far south as New Ulm. On earth, especially over shaded rocks.

Throughout the extreme northern portion of the United States and British America. Common in the colder portions of Europe.

20. *Cladonia mitrula* Tuck. in Darl. Fl. Cestr. ed. 3. 444. 1853.

Primary thallus commonly persistent, composed of irregularly or subdigitately laciniate or crenate, flattish, ascending or suberect, clustered, small or middle-sized squamules, these 1.5 to 4 mm. in length and nearly or quite as wide, ashy to sea-green above and whitish below; podetia arising from the surface of the primary thallus, 0.5 to 15 mm. long and 0.4 to 1.6 mm. in diameter, cylindrical and cupless, always terminated by apothecia, simple or branched toward the apex, the branches suberect or spreading, sometimes fissured longitudinally, the axils sometimes open, clustered or subsolitary, erect, the cortex continuous or composed of contiguous or subcontiguous areoles, or the surface rarely in part decorticate and somewhat sorediate, sometimes more or less squamulose, ashy to sea-green or the decorticate portions whitish; apothecia small or middle-sized, 1 to 2 mm. in diameter, solitary or clustered, sometimes perforate, flat and marginate or convex and immarginate, brown

varying toward paler or reddish brown; hypothecium pale or brownish; hymenium pale or brownish below and brownish above; paraphyses usually simple, commonly thickened and brownish toward the apex; asci clavate.

Frequent in the southern half of the State, but replaced northward by *Cladonia cariosa*. On earth.

Common throughout the United States, especially so toward the south. Not common in British America, but reported as far north as Alaska. Also known in South America.

21. *Cladonia cariosa* (Ach.) Spreng. Syst. Veg. 4: 272. 1827.

Lichen cariosus Ach. Lich. Suec. 198. 1798.

Primary thallus persistent or replaced by new squamules, composed of irregularly lacinate, incised or crenate, concave, flat, involute or revolute, ascending or suberect, clustered or rarely scattered squamules, these small or medium-sized, 1 to 6 mm. long and 1 to 5 mm. wide, pale sea-green above varying toward olivaceous, whitish below or brownish toward the base, the cortex continuous or more or less sorediate above and along the margin; podetia arising from the surface or margin of the squamules, 5 to 30 mm. long and 1 to 2 mm. in diameter, subcylindrical or thickened toward the top, cupless and always terminated by apothecia, usually freely branching, sometimes even from the base, the branches spreading or more usually suberect, the sides commonly more or less fissured or grooved; clustered or subsolitary, usually suberect; cortex subcontinuous or areolate, the areoles frequently scattered, rarely squamulose, more commonly so toward the base, pale sea-green or whitish, the decorticate portions of the surface between the areoles white; apothecia usually medium-sized, 1 to 2 or even 4 mm. in diameter, clustered-conglomerate, frequently perforate, borne at the apices of the podetia, flat or becoming convex and immarginate, lighter or darker brown or possibly rarely reddish brown; hypothecium pale; hymenium brownish above and pale or brownish below; paraphyses simple or rarely branched, thickened and brownish toward the apex; asci clavate or cylindrico-clavate.

Widely distributed in the State, but more common toward the north. On earth or rarely on old wood.

Distributed throughout North America. Found in all the grand divisions.

22. *Cladonia decorticata* (Floerke) Spreng. Syst. Veg. 4: 271. 1827.

Capitularia decorticata Floerke in Weber & Mohr, Beitr. Naturk. 2: 297. 1810.

Primary thallus finally disappearing and usually more or less replaced by new squamules, these lacinate or crenate, somewhat concave or involute, scattered or clustered, usually small, 1 to 4 mm. long and 1 to 2 mm. wide, light sea-green, above varying toward olivaceous, beneath whitish, or brownish toward the base; podetia arising from the surface of the primary thallus, 1 to 10 cm. long and 0.75 to 2 mm. in diameter, cylindrical, cupless, simple or more or less dichotomously or irregularly branched, the branches commonly erect or spreading, the fertile apices often dilated, the sterile ones obtuse or subulate, the sides sometimes fissured; clustered or subsolitary, erect or rarely ascending or even decumbent, variously sorediate, areolate, and squamulose, the latter especially toward the base, decorticate between the areoles or squamules toward the base, pale sea-green or brownish, the decorticate portions white; apothecia middle-sized, 0.75 to 4.5 mm. in diameter, confluent or conglomerate, borne at the apices of the podetia or branches, concave, flat or convex, thinly margined or finally immarginate, usually brown; hypothecium pale; hymenium pale or pale brownish below and brownish above; paraphyses usually simple, commonly thickened and brownish toward the apex; asci clavate or cylindrico-clavate.

Collected in several widely separate localities in the State, but hardly common. On earth and old wood.

Known in the White Mountains of New Hampshire and widely distributed in British America and Alaska. Found also in Europe and Asia.

23. *Cladonia gracilis* (L.) Willd. Fl. Berol. Prodr. 363. 1787.*Lichen gracilis* L. Sp. Pl. 1152. 1753.

Primary thallus usually persistent, composed of irregularly laciniate or crenate, somewhat flat, involute or convolute, ascending, clustered or scattered squamules, these somewhat incrassate, middle-sized, 2 to 5 mm. long and nearly as wide, sea-green varying to olivaceous above, white below or brownish toward the base; podetia arising from the surface of the primary thallus, 10 to 75 mm. long and 0.3 to 5.5 mm. in diameter, cylindrical and cupless or trumpet-shaped and scyphiform, commonly in larger or smaller clusters, erect or ascending, the cortex subcontinuous or composed of contiguous or scattered areoles, rarely squamulose toward the base, the decorticate portions between the areoles sometimes granulose-sorediate; variously sea-green, ashy, olivaceous, or even reddish brown, the decorticate portions white, sometimes dying below and the dead portion becoming dark-colored, simple or more or less branched, the sides sometimes more or less rimose or perforate; cups 0.75 to 6 mm. in diameter, abruptly or gradually dilated, regular or subregular, shallow or deep, the margin dentate or proliferate, rarely proliferate from the center, the ranks from 1 to 5, the lowest 10 to 70 mm. long, when four or five, the whole podetium sometimes longer than the measurements given above; apothecia medium-sized, 1 to 4.5 mm. in diameter, usually lobate-conglomerate and sometimes perforate, commonly borne on short pedicels, these frequently arising singly or in clusters from the margins of the cups, thinly margined or more commonly convex and immarginate, pale or darker brown; hypothecium pale; hymenium pale below and brownish above; paraphyses rarely branched, thickened and brownish toward the apex; asci cylindrico-clavate.

Generally distributed over the State. On earth or rarely on rotten wood.

Widely distributed in North America and cosmopolitan elsewhere.

23a. *Cladonia gracilis dilacerata* Floerke, Clad. Comm. 37. 1828.

Differing from the last in that the cups are usually more irregular and the podetia are squamulose.

Cladonia gracilis anthocephala Floerke^a was recognized by Doctor Wainio among our material, but scarcely differs from the above.

The forms referred to subspecies *dilacerata* are confined to the northern portion of the State. On earth or rotten wood.

Little is known of its North American distribution. Credited to Greenland by Wainio. *Cladonia gracilis hybrida* Tuck.^b may be this in part, though Tuckerman's plant is no doubt for most part the last subspecies above. Well known in Europe.

24. *Cladonia degenerans* (Floerke) Spreng. Syst. Veg. 4: 273. 1827.*Baeomyces degenerans* Floerke, Ges. Naturf. Freund. Mag. 1: 288. 1807.

Primary thallus more or less evanescent, composed of usually medium-sized, irregularly laciniately lobed, flat or somewhat involute or convolute, ascending, scattered, or clustered squamules, these 2 to 12 mm. long and 1.5 to 10 mm. wide, sea-green varying toward olivaceous above and white below or darkening toward the base; podetia arising from the surface of the primary thallus, 10 to 55 mm. long and 0.5 to 3.5 mm. in diameter, more or less irregularly cylindrical or turbinate, erect or ascending, the cortex areolate, with commonly elevated and frequently scattered areoles, the portions between the areoles subtomentose, sometimes squamulose; sea-green varying toward ashy or olivaceous, the decorticate portions white, the sides rarely more or less grooved; occurring in larger or smaller clusters, frequently scyphiform-proliferate; cups 1.5 to 8.5 mm. in diameter, abruptly or gradually dilated, usually more or less irregular, urceolate or shallow, commonly dentate or proliferate, the proliferations arising either from the margin or from the center of the cup and either solitary or radiately arranged, the ranks 1 to 5 in number, the lowest 3 to 20

^a Clad. Comm. 37, 1828,^b Syn. Lich. N. E. 49. 1848,

mm. long, the sterile apices scyphiform, cornute, or rarely subulate; apothecia small to medium-sized, 0.5 to 2.5 mm. in diameter, regular or finally lobate and perforate, solitary or variously clustered at the apices of podetia or proliferations, convex or flat, immarginate, brown varying toward pale or reddish brown; hypothecium pale; hymenium pale below and pale brownish above; paraphyses simple or branched, frequently thickened and brownish toward the apex; asci cylindrico-clavate.

Ours sterile and the spore and apothecial characters taken from European material.

Collected several times along the international boundary and also at Tower and Bemidji. On earth, frequently over rocks.

Appears to be widely distributed in North America, though much of the material is quite uncertain. Known in all the grand divisions.

24a. *Cladonia degenerans euphorea* (Ach.) Nyl. Syn. Lich. 1: 200. 1858.

Cenomyce gonorega euphorea Ach. Syn. Lich. 289. 1814.

Podetia without squamules or the lower portion sparsely squamulose, the sterile cups regular and the fertile ones subregular, sometimes proliferate.

In ours, determined by Doctor Wainio from Kettle Falls, the sides of the podetia are frequently perforate. The plant is sterile, and the determination is one well-nigh impossible to make without authentic specimens.

Collected along the international boundary from Harding to Rainy Lake City. On earth, over rocks.

Not known elsewhere in America. Well known in Europe.

24b. *Cladonia degenerans cladomorpha* (Ach.) Wainio, Act. Soc. Faun. Flor. Fenn. 10: 141. 1894.

Baeomyces alicornis cladomorpha Ach. Syn. Lich. 350. 1814.

Podetia without squamules or sparsely squamulose toward the base, scyphiform, the cups irregular with lacerate and sometimes proliferate margins.

A single collection was made at Emo on the international boundary. On earth, over rocks.

Not known elsewhere in America. Well known in Europe.

25. *Cladonia verticillata* Hoffm. Deutsch. Fl. 2: 122. 1795.

Primary thallus commonly persistent, composed of irregularly subcuneate or crenately lobed, or even incised-lobate, flat or somewhat involute, ascending, clustered or scattered, medium-sized or larger squamules, these 1.5 to 7.5 mm. long and wide, sea-green above or more commonly varying toward ashy, olivaceous, or even brownish, below white or darkening toward the base; podetia arising from the squamules, 3 to 55 mm. long and 0.5 to 3.5 mm. in diameter, tubæform or more rarely turbinate, subsolitary or clustered into small patches, erect or rarely ascending, the cortex subcontinuous, grooved or areolate with commonly closely contiguous areoles, destitute of squamules or rarely more or less squamulose at the base of the podetia or at the margins of the cups, sea-green varying toward ashy, yellowish, brownish, or olivaceous, or variegated with these colors, the narrow decorticate portions between the areoles white or rarely reddish, scyphiform; cups medium-sized or large, 2.5 to 9 mm. in diameter, usually abruptly dilated, shallow, the margin subentire or dentate, commonly proliferate from the closed cavity of the cup, the proliferations 1 to several, and the ranks commonly 2 to 5, the lowest one about 20 mm. long; apothecia small or medium-sized, 0.5 to 2.5 mm. in diameter, rounded or irregular and perforate, sessile on the margin of the cups or shortly pedicellate, flat and thinly margined or becoming convex and immarginate, paler or darker brown; hypothecium pale; hymenium commonly pale below and brownish above; paraphyses simple or rarely branched, commonly thickened and brownish toward the apex; asci cylindrico-clavate.

Generally distributed over the State. On earth, or on rocks covered with humus.

The plant is generally distributed over North America. Known also in all of the grand divisions, and one of the most cosmopolitan of lichens.



GLADONIA PYXIDATA CHLOROPHAEA (SPRENG.) FLOERKE.

25a. *Cladonia verticillata cervicornis* (Ach.) Flot. *Linnaea* 22: 380. 1849.

Lichen cervicornis Ach. *Lich. Suec.* 184. 1798.

Primary thallus persistent, composed of rather large or medium-sized, usually densely clustered, lacinate squamules, these about 5 to 12 mm. long; podetia rather short and slender for the species, 2 to 20 mm. long and 0.3 to 1 mm. in diameter, simple or proliferous from the central portions of the cups, or rarely from the margins or even from the sides of the podetia below the cups, the ranks 1 to 3, the upper ranks often without cups and branched irregularly, without squamules or squamose about the margins of the cups.

Once collected in the State, at Koochiching. On earth.

Elsewhere in North America from New England, Mississippi, and arctic America. Known also in all the grand divisions.

26. *Cladonia pyxidata* (L.) Hoffm. *Deutsch. Fl.* 2: 121. 1795.

Lichen pyxidatus L. *Sp. Pl.* 1151. 1753.

Primary thallus commonly persistent, composed of irregularly or digitately incised or lobate, flat, concave or rarely convex, commonly ascending, clustered or scattered squamules, these 2 to 8 mm. long and 1.5 to 6 mm. wide, sea-green above or varying toward whitish or olivaceous, commonly lighter and sorediate below; podetia arising from the surface of the primary thallus, 3.5 to 30 mm. long and 3 to 4.5 mm. in diameter, turbinate or tubæform, erect, the cortex areolate or verrucose or subcontinuous toward the base, rarely more or less squamulose, sea-green varying toward ashy or olivaceous, the decorticate portion white or ashy-brown, frequently closely clustered, scyphiform; cups 1 to 7 mm. in diameter, regular or irregular, on well-developed podetia or the dilation beginning just above the primary thallus, the cavity non-perforate, sorediate or corticate, entire, dentate or proliferate from the margin, the proliferations 1 or more, the ranks 1 to 3; apothecia scarcely common, medium-sized, 1 to 4 mm. in diameter, solitary or conglomerate, regular or irregular, sessile on the margins of the cups or on longer or shorter pedicels, flat and thinly margined or more commonly convex and immarginate, commonly brown, and ours all of some shade of brown; hypothecium pale or pale brownish; hymenium pale or pale brownish below and brownish above; paraphyses simple or rarely branched, commonly thickened and brownish toward the apex; asci clavate.

Generally distributed over the State. On earth or rotten wood.

Widely distributed in North America. Cosmopolitan in its foreign distribution.

26a. *Cladonia pyxidata chlorophaea* (Spreng.) Floerke, *Clad. Comm.* 70. 1828.

PLATE 17.

Cladonia chlorophaea Spreng. *Syst. Veg.* 4: 273. 1827.

Podetia more or less decorticate and sorediate toward the top.

Thus far found only in the northern portion of the State, but no doubt generally distributed, though not so common as the species.

Reported elsewhere in North America only from Massachusetts, Pennsylvania, and Ohio, and northward to Great Bear Lake, but doubtless generally distributed. Known in all the grand divisions.

EXPLANATION OF PLATE 17.—Plant on an old stump, showing primary thallus and the cup-bearing podetia. Natural size.

26b. *Cladonia pyxidata pocillum* (Ach.) Flot. *Linnaea* 17: 19. 1843.

Baeomyces pocillum Ach. *Meth. Lich.* 336. *pl. 8. f. 6.* 1803.

Primary thallus of rather large and thick, round-lobed or somewhat incised, closely adnate or slightly ascending squamules, these more or less imbricated and closely packed into a commonly olivaceous or brownish crust; podetia simple and sterile, partly decorticate above but not sorediate.

A single collection was made at Grand Marais. On humus over rocks along Lake Superior. Not previously reported from Minnesota.

An arctic and subarctic form widely distributed in British America, and found in Alaska. Known also in Europe, Asia, and Africa.

27. *Cladonia fimbriata* (L.) Hoffm. Deutsch. Fl. 2: 122. 1795.

Lichen fimbriatus L. Sp. Pl. 1152. 1753.

Primary thallus commonly persistent, composed of digitate or irregularly incised or lobate, flat or concave, frequently involute or convolute, ascending, clustered or scattered medium-sized squamules, these 2 to 9 mm. long and wide; sea-green above varying toward olivaceous or whitish, below whitish or darkening toward the base, sometimes sorediate-granulose below and along the edges; podetia arising from the surface of the squamules, 4 to 80 mm. long and 0.5 to 3.5 mm. in diameter, cylindrical to tubæform or rarely turbinate, commonly clustered into larger or smaller groups, erect, or rarely ascending or irregularly curved, commonly decorticate and more or less sorediate, or areolate or verrucose-corticate toward the base or the corticate basal portion even subcontinuous, destitute of squamules or more or less squamulose, especially toward the base; sea-green varying toward whitish or brownish, the decorticate portions commonly whitish, sometimes scyphiform, or the apices frequently cornute or subulate; cups well developed or abortive, abruptly or gradually dilated, regular or irregular, the cavity commonly deep, the margin entire, dentate, or proliferate, the proliferations 1 to several and the ranks 1 to 3; apothecia commonly medium-sized, 0.8 to 2 mm. in diameter, solitary and rounded or irregularly conglomerate; sessile or pedicellate on the margins of the cups or at the cornute or subulate apices, flat and thinly margined or more commonly becoming convex and immarginate, brown or reddish brown; hypothecium pale; hymenium pale or pale brownish below and brownish above; paraphyses rarely branched, commonly thickened and brownish toward the apex; asci clavate or cylindrico-clavate.

Generally distributed over the State, in some of the several following forms. On earth and old wood.

Generally distributed over North America, though the subspecies are not, as a rule, well enough known to permit any definite statement to be made concerning their American distribution. Cosmopolitan also in its foreign distribution.

The subspecies given below are connected by various intermediate forms and altogether form the most confusing assemblage of lichens known to our flora. The best descriptions can do little more than lessen the difficulties of determination.

27a. *Cladonia fimbriata simplex* (Weiss) Wainio, Act. Soc. Faun. Flor. Fenn. 10: 256. 1894.

Lichen pyxidatus simplex Weiss, Pl. Crypt. Gott. 84. 1770.

Podetia scarcely exceeding 3 to 30 mm. in length, scyphiform, the cups well developed, 2 to 7 mm. in diameter, regular or becoming suboblique, with entire or dentate margins, the podetium erect and straight; apothecia sessile or pedicellate on the margins of the cups. Doctor Wainio further divides the variety into two subvarieties.^a

Thus far found only in the northern portion of the State.

The plant is widely distributed in North America. Known also in all the grand divisions.

27b. *Cladonia fimbriata prolifera* (Retz.) Mass. Sched. Crit. Lich. Exsicc. no. 155. 1855.

Lichen fimbriatus prolifer Retz. Fl. Scand. Prodr. 232. 1779.

Podetia 20 to 70 mm. long, scyphiform, repeatedly proliferate from well-developed cups, commonly straight and erect, wholly decorticate and for most part sorediate, or having a minutely areolate or verrucose cortex below, sometimes squamulose, especially toward the base; cups 2 to 10 mm. in diameter, commonly somewhat

^a See Wainio, Act. Soc. Faun. Flor. Fenn. 10: 258. 1894.

abruptly dilated, regular or rarely oblique; proliferations one or more from each cup, the ranks 2 to 3 or rarely more, the upper ranks usually quite as long as the lower and scyphiform, but the terminal cups commonly narrowed; apothecia usually borne on the cups of the higher ranks.

The plant referred to this species was collected at Warroad. On earth in a swamp.

Reported from Vancouver Island and Newfoundland; otherwise unknown in North America outside of Minnesota. Known in Europe, Asia, and South America.

27c. *Cladonia fimbriata cornutoradiata* Coem. Bull. Acad. Roy. Belg. **19**: 40. 1865.

Podetia elongated, sometimes bearing narrowed or abortive cups, simple or branched, the branches cornute or scyphiform, destitute of squamules or squamulose toward the base, decorticate and sorediate, or corticate toward the base and rarely also below the cups, the cavity of the cups sorediate.

This subspecies was collected at Kettle Falls and at Tower. On earth.

Not known elsewhere in North America. Frequent in Europe.

27d. *Cladonia fimbriata radiata* (Schreb.) Nyl. Syn. Lich. **1**: 195. 1858.

Lichen radiatus Schreb. Spic. Fl. Lips. 122. 1771.

Podetia commonly long, 17 to 75 mm. in length, scyphiform, elongate-turbinate or subtubæform, commonly more than 1-ranked, the sterile apices cornute, subulate, or rarely obsoletely scyphiform, commonly straight and suberect, wholly decorticate and sorediate, or corticate and minutely areolate or verrucose toward the base, without squamules or rather rarely squamulose, especially toward the base; cups rather small, 2 to 5 mm. in diameter, gradually or quite abruptly dilated, quite regular or irregular, the margins dentate or proliferate, the proliferations one to several and elongated or quite short, the ranks 2 or 3; apothecia sessile or shortly stalked on the margins of the cups.

For the most part confined to the northern portion of the State, but collected as far south as Redwood Falls. On earth and old wood.

Generally distributed throughout northern North America. Known in all of the grand divisions except South America.

27e. *Cladonia fimbriata subulata* (L.) Wainio, Act. Soc. Faun. Flor. Fenn. **10**: 282. 1894.

Lichen subulatus L. Sp. Pl. 1153. 1753.

Podetia much elongated, 3 to 10 cm. in length, usually cupless, cylindrical, simple or variously branched, the sterile apices obtusely cornute or subulate; erect and straight or subflexuous, especially toward the apex, wholly decorticate and sorediate, or areolate or subcontinuously corticate toward the base, without squamules or more or less squamulose, especially toward the base; apothecia at the apices of the podetia, rather rare.

Throughout the northern portion of the State. On earth, especially over rocks.

Elsewhere in North America known in the White Mountains and on Vancouver Island. Known in all of the grand divisions.

27f. *Cladonia fimbriata nemoxyna* (Ach.) Wainio, Act. Soc. Faun. Flor. Fenn. **10**: 295. 1894.

Baeomyces radiatus nemoxynus Ach. Meth. Lich. 342. 1803.

Podetia commonly 25 to 90 mm. long, scyphiform or subscyphiform, 2 or 3-ranked, the sterile apices abortively scyphiform, cornute or subulate, suberect, more or less flexuous, wholly decorticate and sorediate, or in the basal half (more or less) variously areolate or verrucose-corticate, as also at the base of the apothecia and of the proliferations, without squamules or the basal portions and below the cups squamulose or rarely the whole podetium sparsely squamulose; cups small or abortive, 1 to 3.5 mm. in diameter, gradually or somewhat abruptly dilated, commonly becoming irregular, the margin dentate or proliferate, the proliferations one or more, either short or quite elongated; apothecia sessile or on pedicels on the margin of the cups.

Common throughout the northern half of the State, occurring as far south as Taylors Falls and Granite Falls. On earth, frequently over rocks.

Found elsewhere in North America in a single locality, viz, New Bedford, Massachusetts. Known in all of the grand divisions.

27g. *Cladonia fimbriata coniocraea* (Floerke) Wainio, Act. Soc. Faun. Flor. Fenn. 10: 308. 1894. PLATE 14, B.

Cenomyce coniocraea Floerke, Deutsch. Lich. 7: 14. 1821.

Podetia rather short, commonly 5 to 25 mm. long and 1 to 2 mm. in diameter, cupless and cylindrical or abortively scyphiform, commonly simple or rarely sparsely short-branched toward the apex, the sterile apices subulate, cornute, or abortively scyphiform, commonly straight and erect but sometimes flexuous, wholly decorticate and sorediate, or corticate toward the base and rarely below the cups, the cortex subcontinuous or areolate-verrucose, without squamules or more or less squamulose, especially toward the base; cups small or abortive, 1 to 2 mm. in diameter, terminal with a usually entire and at least nonproliferate margin; apothecia scarcely rare, borne at the apex of the podetia or on the margins of the small cups, commonly subsolitary on very short pedicels.

Generally distributed over the State. Commonly on old and rotting wood.

Wainio does not give the subspecies a wide North American distribution, but it seems that the plants referred to *Cladonia fimbriata tubaeformis*, by Tuckerman belong here or to the next subspecies. This would give a general North American distribution, which doubtless exists. Known also in Europe, Asia, and Australia.

EXPLANATION OF PLATE 14.—See p. 113.

27h. *Cladonia fimbriata apolepta* (Ach.) Wainio, Act. Soc. Faun. Flor. Fenn. 10: 307. 1894.

Baeomyces bacillaris apoleptus Ach. Meth. Lich. 330. pl. 7. f. 6. 1803.

Podetia commonly quite short, cupless or narrowly or abortively scyphiform, wholly decorticate and sorediate or corticate toward the base and rarely below the apothecia.

This subspecies is perhaps rather shorter and more slender than the last, lighter in color, and more frequently squamulose. These remarks are based on the four or five specimens referred here for us by Doctor Wainio, and we admit our inability to distinguish between the two subspecies.

Confined to the northern portion of the State. On old and rotting wood.

If these two subspecies may be regarded as at all distinct, the American and foreign distribution of the two is very similar.

28. *Cladonia pityrea* (Floerke) Fr. Sched. Crit. Lich. Exsicc. Suec. 8: 21. 1826.

Capitularia pityrea Floerke, Ges. Naturf. Freund. Mag. 2: 15. 1808.

Primary thallus finally disappearing, when present composed of subdigitate, lacinate, or crenate, involute, concave or flat, ascending, clustered or scattered squamules, which are 1 to 3 mm. long and 0.5 to 2 mm. wide, sea-green or olivaceous above and white below and rarely more or less sorediate-granulose; podetia arising from the surface of the primary thallus, 3.5 to 50 mm. long and 0.5 to 4 mm. in diameter, tubæform, turbinate, or subcylindrical, scattered or clustered in small patches, usually erect, the cortex subcontinuous and verrucose, or composed of small areoles, the areoles raised and contiguous, sometimes more or less squamulose; sea-green, varying toward ashy or olivaceous, sometimes scyphiform, the cupless and sterile apices obtuse or subulate, simple or digitately or irregularly branched; cups 0.5 to 3 mm. in diameter, gradually or abruptly dilated, commonly more or less irregular, often oblique, the cavity rather shallow, the margin dentate, lacerate, or proliferate, the proliferations one or more and the ranks 1 to 3; apothecia small or medium-sized, 0.5 to 2.5 mm. in diameter, often conglomerate, usually on short pedicels on the margins of the cups

or at the cupless apices, the disk flat and thinly margined or becoming convex and immarginate, commonly brick-red (but ours more often a dark brown); hypothecium pale or pale brownish; hymenium of same color or darker brownish above; paraphyses simple or branched, commonly thickened and brownish toward the apex; asci clavate or cylindrico-clavate.

A single collection from Granite Falls has been placed here by Doctor Wainio, who would refer all well-marked specimens to one of his several forms. On earth.

Recorded by Wainio from several widely separate North American localities and no doubt quite generally distributed, though little known in America. Known in all of the grand divisions and a very widely distributed lichen.

28a. *Cladonia pityrea subacuta* Wainio, Act. Soc. Faun. Flor. Fenn. 10: 355. 1894.

Podetia cupless, only 10 to 35 mm. in length, wholly granulate or sorediate-granulate, or verrucose or areolate-corticate toward the base, seldom bearing squamules.

Part of the material of the same collection has cups, and this Doctor Wainio has referred to subspecies *cladomorpha* (Floerke) Wainio, loc. cit. The material is otherwise wholly similar.

Collected at Emo. On old wood.

Neither form is known elsewhere in North America. Both are more or less common in Europe.

29. *Cladonia botrytes* (Hag.) Willd. Fl. Berol. Prodr. 365. 1787.

Lichen botrytes Hag. Tent. Hist. Lich. 121. pl. 2. f. 9. 1782.

Primary thallus commonly persistent, composed of crenate, incised or variously lacinate, flat, involute or rarely convex, commonly ascending, scattered or rarely clustered squamules, these 1 to 3 mm. long and of about the same width, sea-green, varying toward straw-colored or olivaceous above and white below, sometimes sparsely sorediate or granular; podetia arising from the surface of the squamules, 2 to 18 mm. long, rather slender, cylindrical or subcylindrical, rarely abortively scyphiform, variously branched toward the apex, or simple, or rarely branched toward the base, the branches commonly short or very short, the sides frequently rimose, the axils sometimes open; solitary or in groups, erect or variously curved or flexuous, the cortex verrucose or divided into rather small areoles, these contiguous or scattered, sometimes more or less squamulose, especially toward the base; varying from straw-colored to sea-green, or the decorticate portions straw-colored or whitish; cups rare and abortive, in the axils of branches when present; apothecia terminating all of the podetia or branches, small or rarely middle-sized, commonly 0.4 to 2 mm. in diameter, rounded or irregular, sometimes perforate, frequently clustered or conglomerate, rarely solitary, flat, and margined with a light-colored exciple, or more commonly convex and immarginate, from pale flesh-colored to pale brown, rarely somewhat pruinose; hypothecium pale; hymenium pale throughout or slightly colored above; paraphyses simple, the apex frequently thickened but showing little or no color; asci clavate or cylindrico-clavate.

Throughout the northern portion of the State. On old wood, especially of conifers. Easily passed over as a condition of *Cladonia cariosa* or *Cladonia mitrula*.

Plants from British Columbia, Wisconsin, and New York had been previously referred here by Wainio. Common in Europe and known also in Asia.

Family STEREOCAULACEAE.

The family consists of the two genera *Pilophorus* and *Stereocaulon*. The structure of the thallus and the apothecia will be thoroughly discussed under *Stereocaulon* following, and the family may, for the rest, be disposed of rather briefly.

The relationship of the Stereocaulaceae to the Cladoniaceae in the possession of a primary and a secondary thallus and in apothecial characters is obvious. Indeed, the two families are seldom separated, and if we consider the apothecial characters alone there is certainly no reason for a division. But if we look at the secondary thallus (podetia) of *Stereocaulon* and *Pilophorus* closely it will appear that there is doubt as to whether any of the algæ found in the phyllocladia, or even those rarely found in the loose network of hyphæ, are other than foreign. The absence of a cortex would render the capture of foreign algæ by the outer hyphal layer and the phyllocladia an easy matter, and perhaps we have here, after all, at best only what may be regarded as pseudopodetia. Also the phyllocladia are certainly totally different structures from the squamules of the podetia of the *Cladonias*, but this of itself would give us no more ground for making two families for *Cladonia* and *Stereocaulon* than we should have for separating *Peltigera aphthosa* from the *Peltigeraceae* on account of the cephalodia. Further studies of the podetia must decide whether or not *Stereocaulon* and *Pilophorus* may properly be included with the *Cladoniaceae*. And, indeed, the relationships can scarcely be understood until we know more of the phylogeny of the genera involved. Also, the relative rank of the genera can hardly be decided at present.

STEREOCAULON^a Hoffm. Deutsch. Fl. 2: 128. 1795.

PLATE 18.

The thallus, as in *Cladonia*, consists of a primary and a secondary. The primary thallus, however, is wanting in the mature plant, so that in the descriptions it may be neglected. The secondary thallus is conspicuous and permanent, composed of the podetia. The podetia are fruticose structures, much branched, the whole podetium being variously twisted and irregular. The central portion of each branch of the podetium is composed wholly of hyphæ extending for the most part longitudinally and forming a solid cylinder, immediately surrounding which is a tangled mass of hyphæ, which may be regarded as a medulla. Surrounding this medullary tissue on all sides is a looser layer of hyphæ inclosing the algal cells and extending outward in all directions as warty or isidioid outgrowths, the so-called phyllocladia. There is no cortex in any of the species. Several kinds of algal cells may be looked for even in the same species. All, however, except perhaps *Cystococcus*, which is the most constantly present, may be regarded as foreign. A discussion regarding other algæ present may be found in Schneider's Text-Book of Lichenology.

The apothecia are usually small or of medium size. They are located on the ends of the branches, and are convex or globose, or sometimes quite flattened. The proper exciple commonly disappears. The hypothecium is pale. The hymenium is pale or brownish below and commonly brownish or brown above. The paraphyses are rarely branched. The spores are hyaline, fusiform to acicular, and 4 to several-celled.

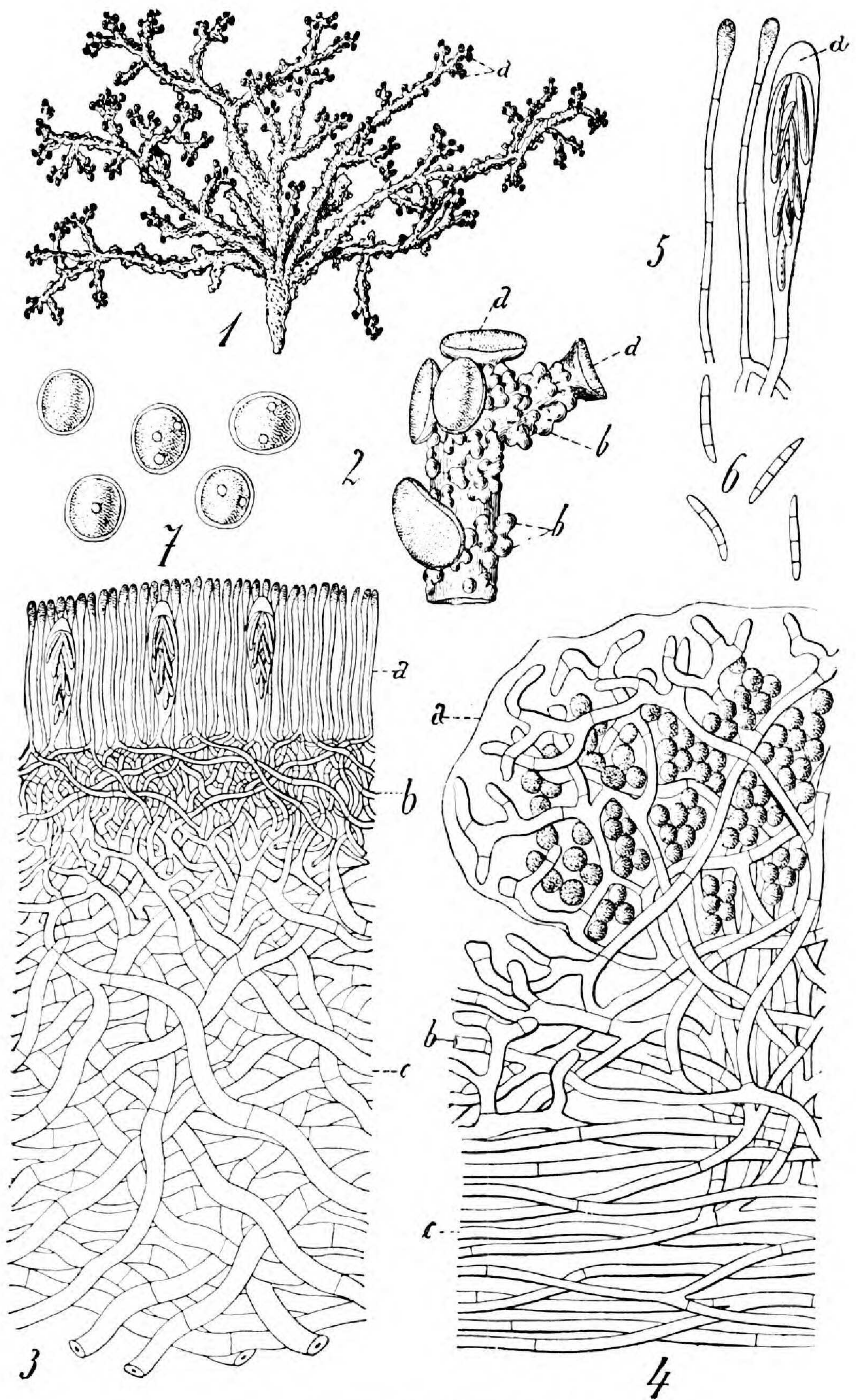
The members of the present genus seem to be closely related to the *Cladonias*, though apparently still more nearly related to *Pilophorus*.

Three species have been reported from the State. On earth over rocks, frequently a very thin layer of humus on a flat rocky surface or in a crevice.

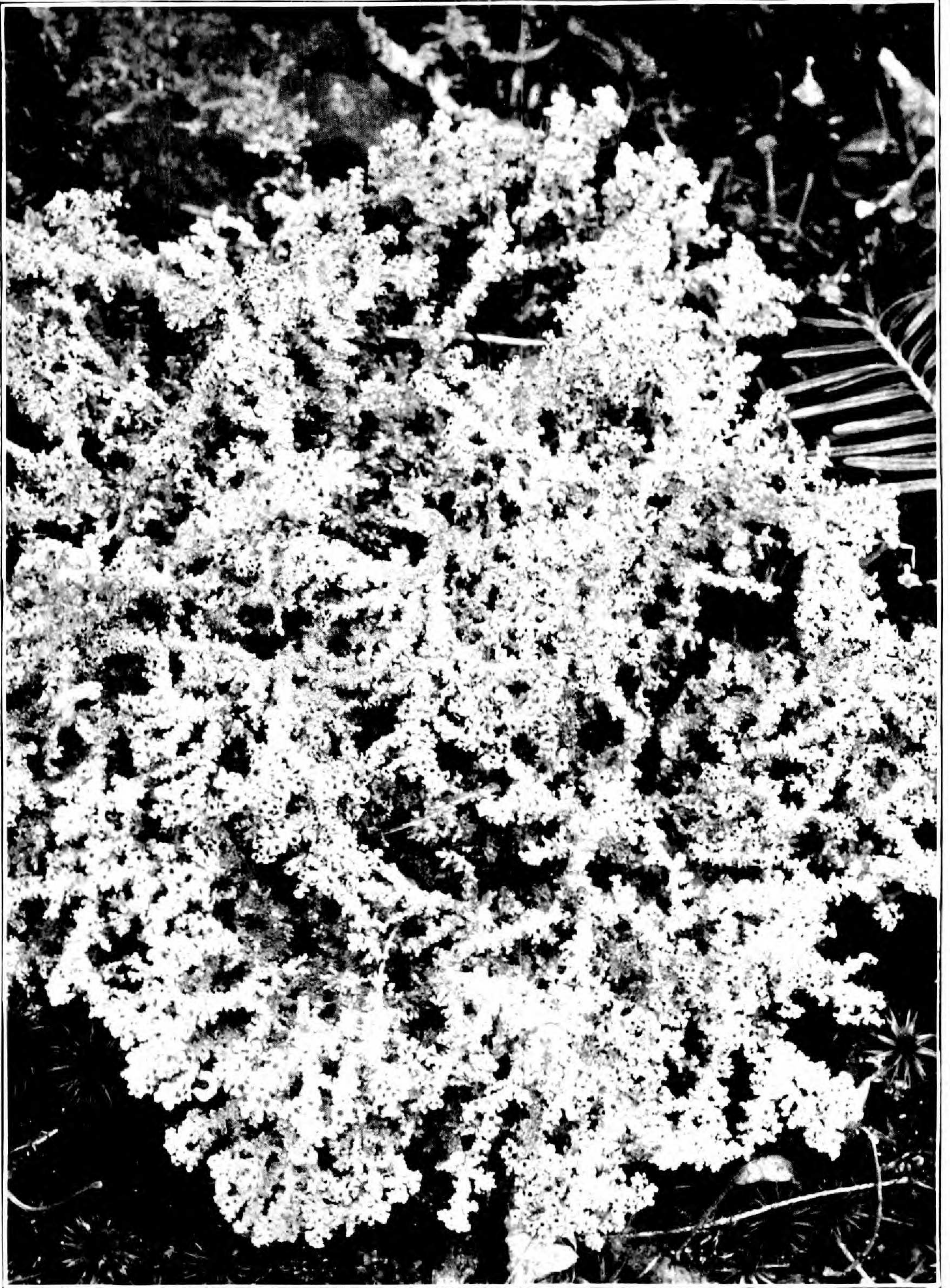
Type species *Stereocaulon corallina* (Wulf.) Hoffm. op. cit. 129.

EXPLANATION OF PLATE 18.—Fig. 1, part of a plant. Fig. 2, *a*, the apothecia; *b*, the phyllocladia. Fig. 3, a section of the apothecium and a portion of the thallus; *a*, the hymenium; *b*, the hypothecium; *c*, the medullary layer. Fig. 4, a longitudinal radial section of a podetium; *a*, a phyllocladium; *b*, the external loose network of hyphæ; *c*, the internal mechanical tissue of longitudinal hyphæ. Fig. 5, paraphyses and (*a*) an ascus. Fig. 6, free single spores. Fig. 7, algal cells. Fig. 1, natural size; fig. 2, enlarged about 10 diameters; figs. 3, 4, enlarged 300 diameters; figs. 5-7, enlarged 650 diameters. From Schneider.

^aThe original spelling is followed.



STEREOCAULON CORALLOIDES FR.



STEREOCAULON TOMENTOSUM FR.

KEY TO THE SPECIES

- Branches of the podetia smooth and naked below..... 1. *S. coralloides*.
 Branches of the podetia not always smooth and naked below.
 Branches of the podetia often slightly tomentose between
 the phyllocladia..... 2. *S. paschale*.
 Branches of the podetia densely white-tomentose..... 3. *S. tomentosum*.

1. **Stereocaulon coralloides** Fr. Sched. Crit. Lich. Exsicc. Suec. 4: 24. 1827.

PLATE 18.

Podetia erect or ascending, occurring in dense clusters, 3 to 7.5 cm. long, rather slender and irregularly compressed-cylindrical, much branched above, smooth and naked below, sea-green varying toward ashy or brownish; phyllocladia more or less scattered, ashy-whitish, passing into digitately divided, coralloid, commonly crowded branchlets; apothecia small to middle-sized, 0.3 to 2 mm. in diameter, terminal or subterminal and often more or less clustered, the disk commonly brown, at first flat and surrounded by the lighter-colored exciple, but becoming convex and the exciple disappearing; hypothecium pale; hymenium pale or brownish below and darker above; paraphyses simple or rarely branched, commonly enlarged and brownish toward the apex; asci clavate or narrowly-clavate; spores commonly 4-celled, 20 to 35 μ long and 3 to 4.5 μ wide.

Collected on Carlton Peak. On humus over rocks.

In the mountains of New England and South Carolina, and common northward throughout British America. Known also in Europe and Asia.

2. **Stereocaulon paschale** (L.) Hoffm. Deutsch. Fl. 130. 1795.

Lichen paschalis L. Sp. Pl. 1153. 1753.

Podetia erect, ascending, or subdecumbent, somewhat longer than those of the last, 3.5 to 10 cm. long, usually rather slender, but somewhat stouter than those of the last, occurring in dense clusters, the clusters sometimes 20 cm. in diameter, more or less compressed and somewhat irregularly cylindrical, slightly tomentose or nearly naked, much branched; phyllocladia ashy or varying toward sea-green, passing into short squamulose and crenate branchlets; apothecia terminal or subterminal, on the whole somewhat larger than in the last, brown or reddish brown, the disk flat and with lighter proper exciple or becoming more or less convex and the exciple disappearing; hypothecium pale; hymenium commonly of the same color below and brownish above, or both hypothecium and hymenium darker; paraphyses simple or rarely branched, commonly enlarged and brownish toward the apex; asci clavate; spores much as in the last, but becoming more than 4-celled more frequently.

Distributed throughout the northern portion of the State and once collected as far south as Redwood Falls. On humus over rocks.

Found in New England and northward throughout British America and Alaska. Known in Europe and Asia.

3. **Stereocaulon tomentosum** Fr. Sched. Crit. Lich. Exsicc. Suec. 3: 21. 1827.

PLATE 19.

Podetia of about the same length as those of the last, but commonly stouter and somewhat more regularly cylindrical, also rather more loosely tufted and even subsolitary, densely whitish-tomentose, divaricately branched, the branches much divided above; phyllocladia grayish white or perhaps more commonly varying toward greenish, becoming squamule-like and blunt-toothed or finger-lobed, crowded on the upper side, but almost wanting beneath; apothecia in ours at least rather smaller or even minute, scarcely reaching more than 0.75 mm. in diameter, subterminal or lateral, frequently more or less clustered, the disk brown, at first flattish and surrounded by the exciple, soon becoming convex and the exciple disappearing; hypothecium pale; hymenium pale or brownish below and darker above; paraphyses

simple or rarely branched, commonly enlarged and brownish toward the apex; asci clavate or cylindrico-clavate; spores as in the first species, or sometimes a little narrower.

Collected on Oak Island in Lake of the Woods and on Grand Portage Island. On earth over rocks.

Found in mountainous regions in the United States, as the mountains of New England, the Rocky Mountains, and Mount Hood (Oregon), and in the mountains of Mexico. Also generally distributed in British America and Alaska. Known also in South America, Europe, and Asia.

EXPLANATION OF PLATE 19.—Plant on rocks; a top view giving an undue depressed appearance, but showing the much-branched podetia covered with phyllocladia and the apothecia. Natural size.

PILOPHORUS Th. Fr. Ster. Pil. Comm. 40. 1857.

The thallus, like that of *Cladonia* and *Stereocaulon*, consists of primary and secondary, but the primary is very poorly developed, consisting of a verrucose crust which is so inconspicuous and evanescent that no account is usually taken of it in descriptions of species. The podetia forming the secondary thallus are simple or very sparingly branched. The central portion of each podetium is composed of a loose network of hyphæ, which may fill the whole center of the cylinder, or may be absent from the axial line, leaving the podetium hollow at the center. Immediately surrounding this central portion is the mechanical tissue, consisting of densely packed hyphæ extending longitudinally. The podetia are without cortex and are clothed more or less with phyllocladia containing the algæ, which are of the genus *Cystococcus*.

The apothecia are small or of medium size and are globose, subglobose, or elongated. They are terminally disposed upon the podetia and are black externally. The hymenium is also black and very tough and stout. The paraphyses are black or bluish black tipped. The spores are hyaline, simple, ellipsoid or fusiform.

The genus differs from *Stereocaulon* mainly in point of the dark and tough character of the apothecia and in having simple spores.

A single species has been found in the State.

Type species *Pilophorus robustus* Th. Fr. op. cit. 41.

1. *Pilophorus cereolus* (Ach.) Tuck. Syn. N. A. Lich. 1: 235. 1882.

Lichen cereolus Ach. Lich. Suec. 89. 1798.

Podetia erect, rigid, cylindrical or subcylindrical, simple or rarely bearing 2 to 5 branches, clustered or scattered over the substratum, short and stout or more slender and elongated, 5 to 40 mm. long, the apex often subulate in sterile specimens, solid or rarely hollow; phyllocladia minute, rounded or becoming flattened and squamule-like, sea-green to ashy or rarely olivaceous; apothecia about 1.5 mm. in diameter, subglobose; spores fusiform, 17 to 20 μ long and 5 to 7 μ wide.

Ours is sterile and the apothecial and spore characters are taken from Nylander.

Collected on rocks at Grand Marais. Not previously reported from Minnesota.

Widely distributed in the northern United States and British America. Known also in Asia, Australia, and Africa.

Family COLLEMACEAE.

This family is one of the best defined groups of lichens, being quite distinct from any other group, both in the structure of the thallus and in the character of the algal symbiont.

The thallus is foliose, but either has no cellular cortex or possesses a single layer of cells above and one below. Nor are the internal layers well differentiated, the algal cells being scattered throughout the thallus, except in the single-layered cortex when this structure is present. In all of ours the algal symbiont is a form of *Nostoc*, and the heterocysts are easily made out. The thallus is more or less gelatinous when wet in all of our species, a condition due to a swelling of the gelatinous sheath of the algal

filaments. The fungal hyphæ frequently lie in contact with the sheath of the algal filaments, but there are no haustoria, and the relation of the two symbionts is not so close as in most other lichens. The thallus is peculiar in two of the genera in being foliose in form and still without cortex, in this respect like crustose thalli. The foliose condition here is of course due to the peculiar nature of the algal symbiont, which quite largely determines the form of the thallus.

The apothecia more commonly show a thalloid exciple, but are on the whole more nearly biatoroid than those of any family following. The family is, therefore, placed near the Lecideaceae, though there is much room for difference of view as to the relative position of the present family and several to follow. However, as to spore characters some of the families next to follow seem lower than the present one. With respect to the spores, the Collemaceae seem nearest to the Pannariaceae.

SYNECHOBLASTUS Trev. Caratt. Gen. Collem. 2. 1853.

The thallus is foliose, but is frequently extended above into marginal or submarginal rugose lobes which give a cespitose-fruticose appearance, sometimes wholly obscuring the horizontal portion even to the center of the thallus. In the higher forms of the genus, the thallus is quite expanded. The cortical layers of the thallus are wholly absent, nor is there any distinct algal layer. On the other hand, the algæ, which consist of a species of Nostoc, showing the heterocysts plainly, are scattered throughout the entire thallus. The algæ occur in chains, which are rather more numerous toward the upper surface of the thallus, or not infrequently quite as numerous toward the lower sides. The chains of algal cells are easily distinguishable, though possibly on the whole hardly so long as in *Collema*. The color of the thallus is bluish, olivaceous, or black, and usually lighter below than above. The thallus may be attached to the substratum by direct adhesion of the lower surface or by rather sparingly developed simple rhizoids.

The apothecia are rather small and are ordinarily developed in all but one of our species. The thalloid exciple is commonly present and extends somewhat above the disk. The color of the disk is generally brown or brownish black, and it is usually flat or slightly convex. The hypothecium is commonly pale or pale brownish, and the hymenium pale below and brownish above. The paraphyses are ordinarily simple, though branched forms may be found in all the species. The spores are hyaline, from 2 to several-celled, but never muriform.

We have divided the genus *Collema* as conceived by Tuckerman, placing in that genus those species having more or less muriform spores and in the present one those not so divided. There seems to be a gradual evolution of spore characters running through the two genera, which are very closely related. The relation of both genera to *Leptogium* is also a close one, *Collema*, as to spore characters at least, seeming to be intermediate between the other two.

A half dozen forms occur in the State. On trees and more rarely on rocks.

Type species *Collema nigrescens* (Huds.) Ach. loc. cit. (*Synechoblastus nigrescens* (Huds.) Stizenb.)

KEY TO THE SPECIES.

Thallus lobes quite closely attached to the substratum.

Spores several-celled, long and narrow; apothecia pruinose... 4a. *S. nigrescens leucopeplus*.

Spores as above; apothecia not pruinose..... 4. *S. nigrescens*.

Thallus lobes not closely attached to the substratum.

Erect or nearly so.

Spores 2-celled..... 1. *S. pycnocarpus*.

Spores 4-celled..... 2. *S. cyrtaspis*.

Ascending.

Spores 4 to 6-celled, rather short and wide..... 3. *S. flaccidus*.

Spores 4 to 8-celled, longer and narrower..... 5. *S. ryssoleus*.

1. **Synechoblastus pycnocarpus** (Nyl.) Fink.

Collema pycnocarpum Nyl. Syn. Lich. 1: 115. 1858.

Thallus foliose and suborbicular, middle-sized, 15 to 65 mm. in diameter, sometimes ribbed and here and there perforate, the lobes long and more or less branched and rising at the margins into a usually erect position, the erect portions densely rugose-lobulate, more or less obscuring the flat parts below, especially when, as at length, covered with the apothecia; adhering to the substratum and also attached by scattered rhizoids, greenish, olivaceous, or blackish, lighter colored below; algal chains distinctly more numerous toward the upper and lower surfaces; apothecia small, 0.4 to 1 mm. in diameter, sessile, the disk brown or reddish brown, becoming convex and irregular and sometimes covering the thalloid exciple, this, when present, having an entire margin; hypothecium commonly pale; hymenium pale below, and pale brownish above; paraphyses simple or rarely branched, commonly enlarged and brownish toward the apex; asci clavate; spores 2-celled, ovoid-ellipsoid, 11 to 16 μ long and 4 to 6.5 μ wide.

Hardly a common Minnesota lichen, but widely distributed in the State. On tree trunks.

Widely diffused in the United States east of the Rocky Mountains and northward into Canada. A strictly American plant, known also in South America.

Collema pycnocarpum of the preliminary reports.

2. **Synechoblastus cyrtaspis** (Tuck.) Fink.

Collema cyrtaspis Tuck. Proc. Amer. Acad. 5: 387. 1862.

Thallus quite similar to that of the last, but on the whole larger and more distinctly lobed, the coloration as above; apothecia said to be larger, reaching 2 mm. in diameter, and more scattered, the thalloid margin more persistent and commonly crenulate; spores 4-celled.

It is the last character which more than any other seems to separate the species from the last above.

Determined from Vermillion Lake by H. Willey. On tree trunks. We have not examined the plant microscopically.

Quite widely distributed throughout the eastern half of the United States and northward into Canada. Not known elsewhere.

Collema cyrtaspis of the preliminary reports.

3. **Synechoblastus flaccidus** (Ach.) Trev. Caratt. Gen. Collem. 1853.

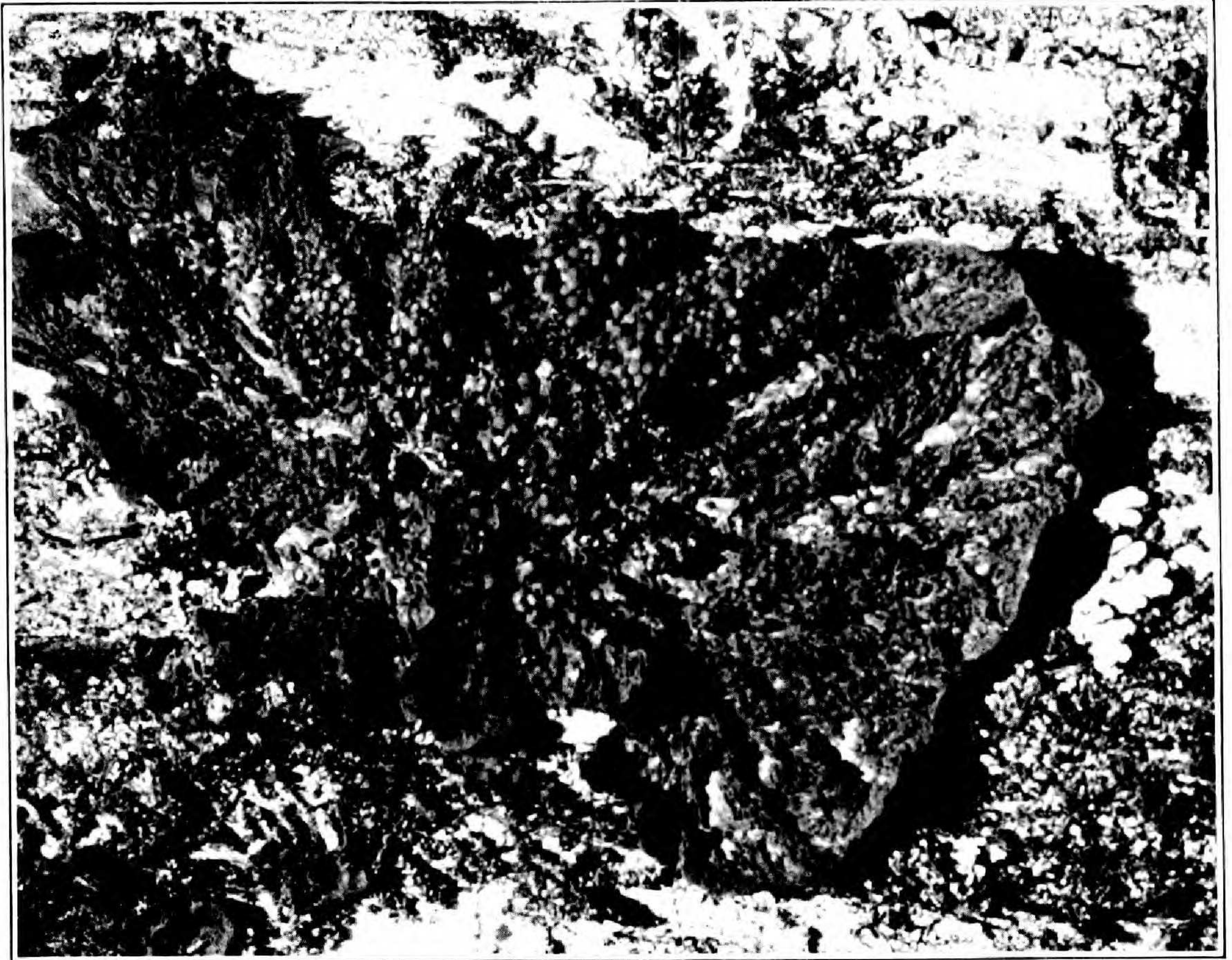
Lichen flaccidus Ach. Vet. Akad. Handl. 16: 14. 1795.

Thallus foliose and suborbicular, middle-sized, 2 to 7 cm. in diameter, somewhat more loosely attached to the substratum than other species (disregarding, of course, the erect lobes of the last two species), and scarcely so gelatinous when wet as the two above; composed of rather wide, rounded, entire lobes, these more or less imbricate and clothed frequently with granules of the same color as the thallus, the color above olivaceous, commonly varying toward black and less frequently toward greenish, usually lighter below; rhizoids few and weak and the plants more usually adhering to the rocks; algal cells slightly more numerous toward the upper surface; apothecia small and sessile, seldom present in ours, 0.5 to 1 mm. in diameter, the disk reddish brown, flat or convex, the margin entire and frequently granulate; hypothecium pale to brownish; hymenium pale below and brownish yellow above; paraphyses simple or rarely branched, the apices usually enlarged and brownish; asci clavate; spores 4 to 6-celled, fusiform-oblong, 20 to 26 μ long and 6 to 8 μ wide.

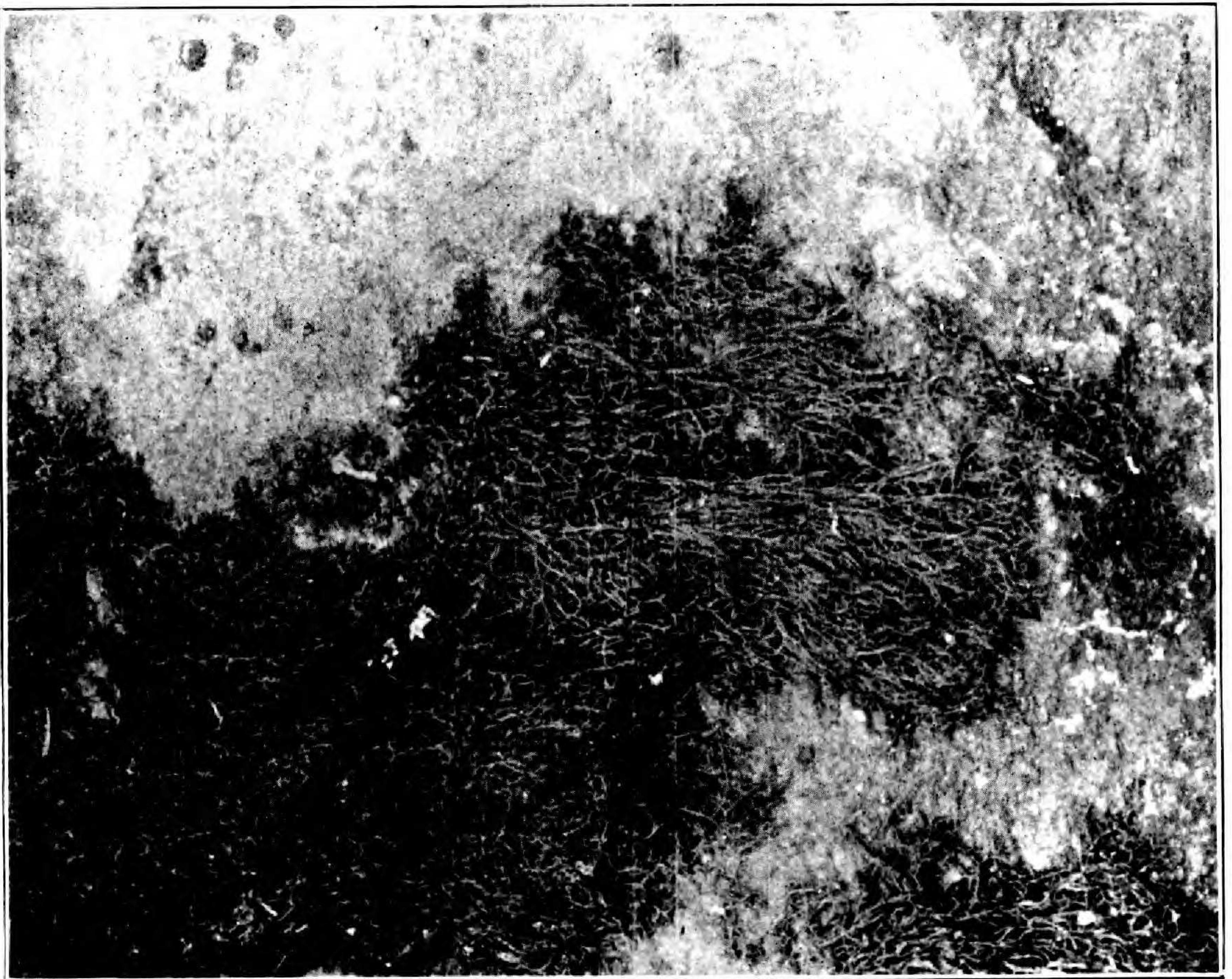
Generally distributed over the State, but not common anywhere. On trees and rarely on rocks.

Widely distributed in North America. Common also throughout Europe.

Collema flaccidum of the preliminary reports.



A. SYNECHOBLASTUS NIGRESCENS (HUDS.) STITZENB.



B. EPHEBE PUBESCENS (L.) FR.

4. *Synechoblastus nigrescens* (Huds.) Stizenb. Ber. St. Gall. Ges. Naturw. 1861-62: 144. 1862. PLATE 20, A.

Lichen nigrescens Huds. Fl. Angl. 450. 1762.

Thallus foliose and commonly orbicular, middle-sized, 30 to 75 mm. in diameter, closely adnate, rather thin, closely beset with pustules on many of which are commonly situated apothecia, or the pustules largely absent and replaced by radiating ridges, the short, rounded marginal lobes entire and usually more or less raised; olivaceous-green and blackening, below lighter and marked by depressions corresponding to the pustules or ridges of the upper surface; algal cells rather more numerous toward the upper surface, rhizoids few and weak and scarcely of use as attaching organs; apothecia small, 0.5 to 1.25 mm. in diameter, sessile, frequently numerous and nearly obscuring the thallus, the disk brown or reddish brown, becoming convex, the thin margin sometimes disappearing; hypothecium pale; hymenium pale below and brownish above; paraphyses simple, or rarely branched toward the frequently enlarged and brownish apex; asci clavate; spores long-fusiform and acicular, several-celled, 50 to 72 μ long and 4 to 6.5 μ wide.

Confined to the northern portion of the State. On trees, especially poplars.

Widely distributed in North America. Known in all the grand divisions except South America.

Collema nigrescens of the preliminary reports.

EXPLANATION OF PLATE 20.—A, plant of *Synechoblastus nigrescens* on poplar, showing the foliose thallus and the rather inconspicuous apothecia. B, plant of *Ephebe pubescens* on rocks, showing the fruticose thallus, whose form is determined by the algal symbiont *Sirosiphon*.^a A and B enlarged 2 $\frac{3}{4}$ diameters.

4a. *Synechoblastus nigrescens leucopeplus* (Tuck.) Fink.

Collema nigrescens leucopepla Tuck. Gen. Lich. 92. 1872.

Apothecia white-pruinose, said to be smaller, as also the whole plant. Ours scarcely distinct and possibly not the subspecies.

Frequent in the northwestern portion of the State, along the boundary especially. On trees.

A North American form, previously reported from several southeastern States. Ours quite as distinct as the material distributed in "Lichenes Boreali-Americani," number 114, from South Carolina.

Collema nigrescens leucopepla of the preliminary reports.

5. *Synechoblastus ryssoleus* (Tuck.) Fink.

Collema nigrescens ryssoleum Tuck. Lich. Calif. 34. 1866.

Thallus commonly orbicular, less closely attached to the substratum than the last, in the material at hand 20 to 45 mm. in diameter, rather smooth above, the rounded lobes ascendant with plicate-undulate and crisped margins, rugose-papulose above; olivaceous or at length blackish brown, beneath paler and reticulate-lacunose; algal cells rather more numerous toward the upper surface; rhizoids few and weak, and the gelatinous thallus here and there directly adnate to the substratum; apothecia small, 0.5 to 1.5 mm. in diameter, sessile, scattered or crowded, the disk brown or reddish brown, flat or convex, the thin entire margin sometimes disappearing; hypothecium pale brownish; hymenium pale below and brownish above; paraphyses simple or branched toward the apex, there also frequently thickened and brownish; asci clavate; spores ovoid and becoming subacicular, 4 to 8-celled, 22 to 26 μ long and 5 to 7 μ wide.

Collected on poplar at Bemidji. The material was scanty and the habitat unusual for the species, but the plant was more like the present externally, and the spore measurements preclude its belonging to the last above.

Otherwise known throughout the eastern United States and as far west as Ohio. Not found recorded for any locality outside of the United States.

Collema ryssoleum of the preliminary reports.

^a See footnote, p. 23.

COLLEMA (Hill.) Web. in Wig. Prim. Fl. Hols. 89. 1780.

PLATE 21.

The thallus is foliose and, like the last, is inclined to be irregular, though on the whole somewhat orbicular. Taken all together, the thalli of the members of the genus are the most gelatinous of all lichen thalli. As in the last, also, the cortical layers are entirely wanting, nor is there a distinct algal layer. The algæ are plainly forms of the genus *Nostoc*, and the heterocysts may usually be plainly seen. The chains of algal cells are quite long and variously curved, and are commonly somewhat more numerous toward the upper side of the thallus. The common color is bluish-olivaceous or blackish. The attachment of the thallus is as in the last genus.

The apothecia are on the whole larger than those of the last genus and are hardly so numerous, though found more or less frequently in all of our species. A thalloid exciple is commonly present and extends somewhat above the margin of the disk. The common color of the disk is some shade of brown, and it may be flat, concave, or convex. The hypothecium is pale or brownish as is also the hymenium. The paraphyses are commonly simple, but branched ones may be found in any of the species. The spores are commonly pale or hyaline, though always more or less muriform when fully mature.

The genus is intermediate between *Synechoblastus* and *Leptogium*, but much closer to the former genus, with which it agrees as to thallus structure. As regards the spores, however, it is perhaps nearer to the latter.

Seven forms have been reported from the State. On earth, or more rarely on rocks or over mosses. Found in moist places.

Type species *Collema lactuca* Web. loc. cit. This is the same as *Synechoblastus nigrescens* (Huds.) Stizenb., hence *Collema* must in all probability replace *Synechoblastus*, and some other name be substituted for it in its present acceptance.

EXPLANATION OF PLATE 21.—Fig. 1, a plant showing the thallus and the apothecia. Fig. 2, a lobe of the thallus with apothecia. Fig. 3, a section of an apothecium; *a*, the hymenium; *b*, the hypothecium; *c*, the inner thallus with hyphæ and algal filaments; *d*, the ventral horizontal hyphæ; *e*, the rhizoids. Fig. 4, a section of the thallus; *a*, the algal filaments; *b*, the fungal hyphæ; *c*, algal filaments; *d*, the rhizoids. Fig. 5, a paraphysis and an ascus. Fig. 6, free muriform spores. Fig. 7, algal filaments. Fig. 1, natural size; fig. 2, enlarged about 4 diameters; figs. 3, 4, enlarged 400 diameters; figs. 5-7, enlarged 650 diameters. From Schneider.

KEY TO THE SPECIES.

On rocks.

Thallus lobes somewhat broad and short, rounded..... 6. *C. furvum*.

Thallus lobes narrower and longer.

Apothecia sessile or subpedicellate on the somewhat narrowed and ascending lobes..... 5. *C. plicatile*.

Apothecia adnate on the narrower, often ascending lobes..... 7. *C. pustulatum*.

On earth.

Thallus rather thick (rarely on mossy rocks)..... 1. *C. pulposum*.

Thallus thinner.

Spores usually four in each ascus..... 4. *C. limosum*.

Spores eight in each ascus.

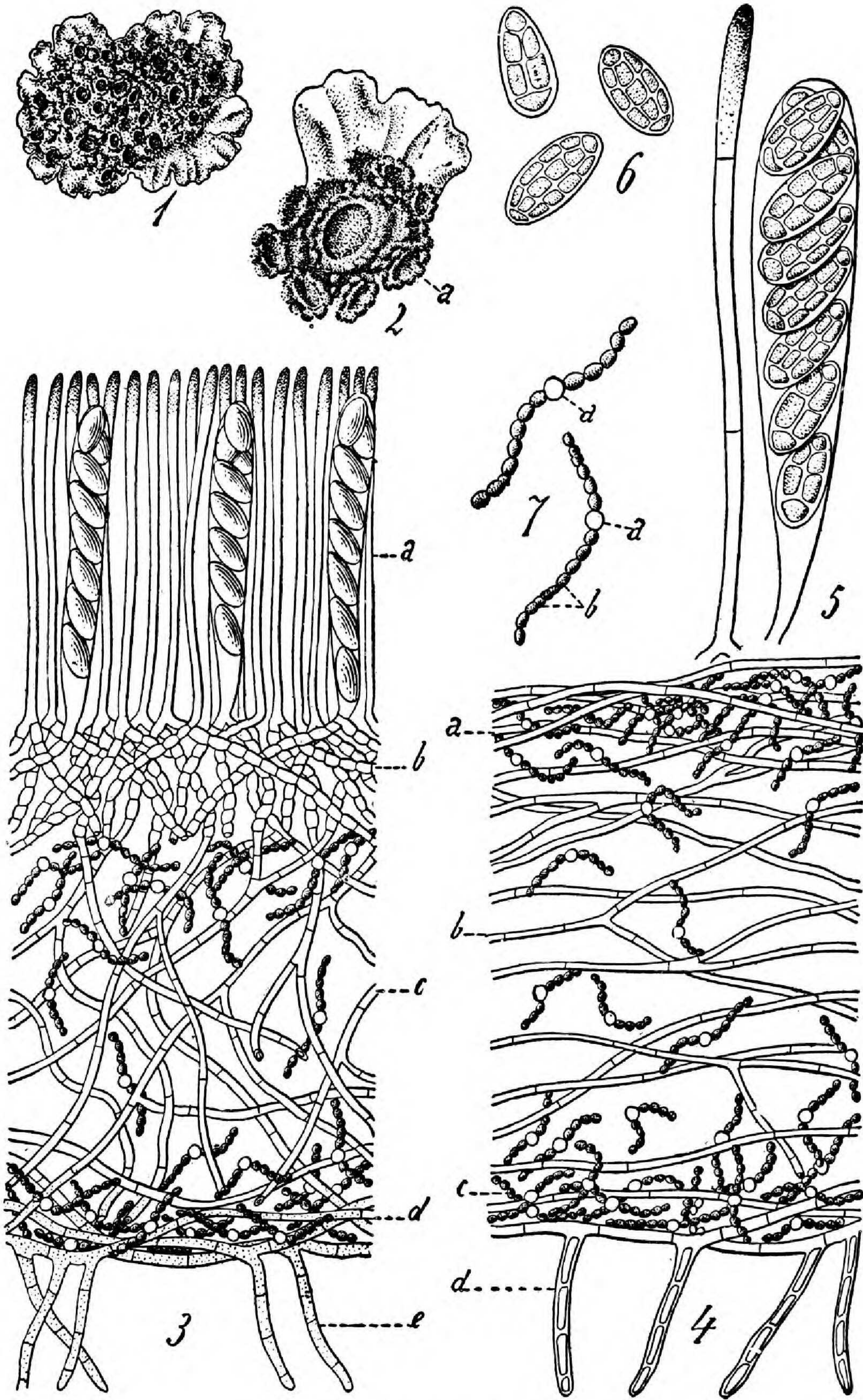
Apothecia numerous, not often deeply immersed.... 3. *C. crispum*.

Apothecia fewer and more often deeply immersed. 2. *C. tenax*.

1. *Collema pulposum* (Bernh.) Ach. Lich. Univ. 632. *pl. 14. f. 9.* 1810.

Lichen pulposus Bernh. Journ. Bot. Schrad. 1799¹: *pl. 1. f. 1.* 1799.

Thallus usually more or less orbicular, middle-sized, 15 to 80 mm. in diameter, very gelatinous when wet, frequently showing a rosulate arrangement of the lobes or granules; rather thick, the thick lobes repand-crenate and often imbricated, especially toward



COLLEMA PULPOSUM (BERNH.) ACH.

the center where the thallus is thicker, the margins somewhat explanate, the central lobes frequently reduced to mere granules; leek-green, olivaceous, or blackening above and scarcely lighter below; rhizoids few and weak; algal cells quite prominently aggregated toward the top and bottom of the thallus; apothecia small or middle-sized, adnate or more or less immersed, 0.75 to 2.5 mm. in diameter, the disk commonly flat or concave, reddish brown, the thalloid margin entire or rarely crenate; hypothecium pale or brownish; hymenium pale below and pale brownish above; paraphyses simple or rarely branched, commonly enlarged and brownish toward the apex; asci clavate; spores ovoid-ellipsoid, from 4-celled becoming somewhat muriform, pale or hyaline, 17 to 25 μ long and 8 to 12 μ wide.

Generally distributed over the State. On earth or mossy rocks, more common in calcareous regions.

Widely distributed in North America, and still not reported from a large number of localities. Known also in Asia, Europe, and Africa.

2. *Collema tenax* (Sw.) Ach. Lich. Suec. 128, 237. 1798.

Lichen tenax Sw. Nov. Act. Soc. Sci. Ups. 4: 249. 1784.

Thallus usually more or less orbicular, rather thin, the lobes expanded and closely adnate, or rarely becoming more or less raised and complicate, yellowish-green or darkening; rhizoids as in the last, but the algal cells less distinctly aggregated toward the top and bottom of the thallus; plant commonly of about the same size as the last, but the thallus of ours usually very small and poorly developed; apothecia smallish, 0.5 to 2 mm. in diameter, commonly more or less immersed in the thallus, the disk usually flat or concave, reddish brown, the thalloid margin entire or crenate; hypothecium brownish; hymenium pale below and brownish above; paraphyses simple or rarely branched, commonly thickened and brownish toward the apex; asci clavate; spores as in the last.

Hardly more than a subspecies of the last.

A single collection has been made in the State at Mankato. On earth.

Distributed throughout the eastern half of the United States and northward into British America. Known also in Europe.

3. *Collema crispum* (Huds.) Hoffm. Deutsch. Fl. 2: 101. 1795.

Lichen crispus Huds. Fl. Angl. 447. 1762.

Thallus more or less orbicular, in ours smallish, 15 to 30 mm. in diameter, rather thin, the marginal lobes somewhat expanded, those of the center with raised plicate and dentate-granulate edges; olivaceous varying toward green or darker color; rhizoids few and the thallus adhering to the substratum; algal cells more or less aggregated toward the top and bottom of the thallus; apothecia frequently numerous and nearly concealing the central portion of the thallus, small or middle-sized, 0.8 to 2.5 mm. in diameter, less inclined to be immersed, the disk more or less concave, dark reddish brown, the margin crenate-granulate or more rarely entire; hypothecium brownish; hymenium pale below and brownish above; paraphyses simple or rarely branched, commonly enlarged and brownish toward the apex; asci clavate; spores oblong-ellipsoid, pale or hyaline, from 4-celled becoming more or less muriform, 16 to 30 μ long and 8 to 12 μ wide.

The apothecia are deeply concave in ours. Like the last, the present is closely related to the first species, of which it may be regarded as a subspecies.

Collected at Bemidji and on the islands belonging to the United States in Lake of the Woods. On earth.

Throughout the northern half of the United States from Colorado eastward, and extending across the continent in British America. Known also in Europe, where it is usually regarded as a form of *Collema pulposum*.

4. Collema limosum Ach. Lich. Suec. 126, 236. 1798.

Lichen limosus Ach. Lich. Suec. 126. 1798.

Thallus thin, in ours usually consisting of scattered and inconspicuous greenish to olivaceous squamules, these usually more or less obscured by the apothecia, sometimes becoming larger and lobate, the lobes then dentate-crenate or narrowed into ascending, blunt lobules; rhizoids few, the algal cells more numerous toward the top and bottom of the thallus, when best developed, rather smaller than those of the last; apothecia commonly immersed, but becoming superficial, smallish or becoming larger than in the last, 1 to 3 mm. in diameter, the disk reddish brown, usually flat, the thalloid margin rather thin and prominent; hypothecium brownish; hymenium pale below and brownish above; paraphyses simple or rarely branched, enlarged and brownish toward the apex; asci clavate; spores pale, muriform-multilocular, 23 to 37 μ long and 10 to 14 μ wide, commonly 4 in each ascus.

Collected at Bemidji and at Koochiching. On earth.

Distributed across North America, but not known in the southern portion of the United States. Known also in Europe and Asia.

5. Collema plicatile Ach. Lich. Suec. 129, 237. 1798.

Lichen plicatilis Ach. Vet. Akad. Handl. 16: 11. pl. 1. f. 2. 1795.

Thallus irregular or suborbicular, small, ours from 5 to 25 mm. in diameter, rather thicker than that of the last two, the more or less imbricated lobes usually ascending or erect with plicate-crested margins, dark-green or more commonly blackening, or rarely dark olivaceous and scarcely lighter below; rhizoids very few and the thallus only attached toward the center or at one side; algal cells more numerous toward the top or in the more erect portions toward both surfaces; apothecia small, 0.4 to 1 mm. in diameter, frequently short-pedicellate, the disk brown and darkening, commonly more or less concave, the margin entire; hypothecium brownish; hymenium pale below and brownish above; paraphyses simple or rarely branched, commonly enlarged and brownish toward the top; asci clavate; spores ovoid-ellipsoid, pale, more or less muriform, 18 to 28 μ long and 6 to 8 μ wide.

Collected at Mankato. On calcareous rocks.

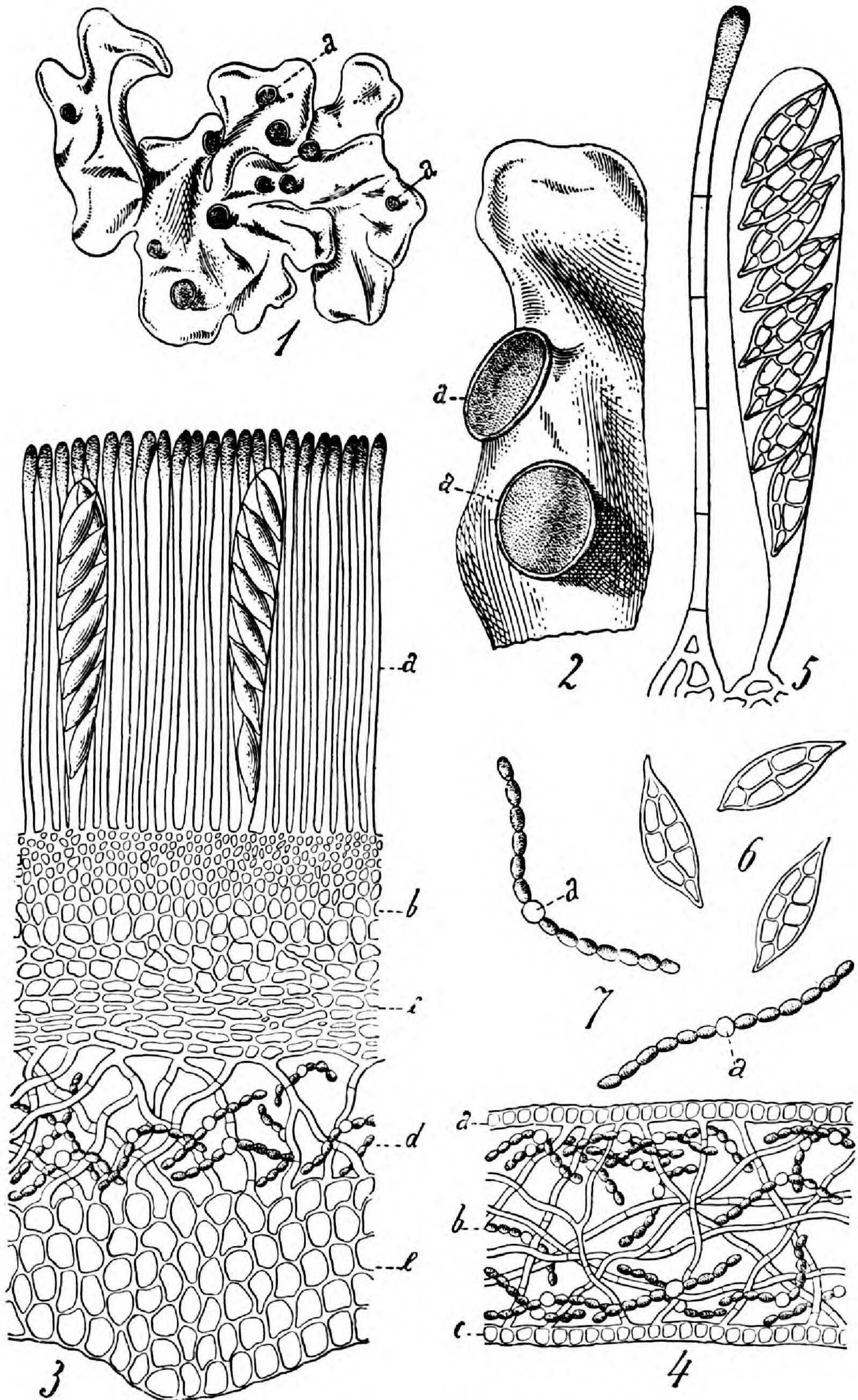
The species was reported from Iceland by Tuckerman, and H. E. Hasse records it from California. The writer has found it also in Iowa. The specimens so reported are in each case differently named. The synonymy must at best be regarded as very uncertain. Known also in Europe and Africa.

6. Collema furvum Ach. Lich. Suec. 132, 236. 1798.

Lichen furvus Ach. Lich. Suec. 132. 1798.

Thallus orbicular or irregular, small or middle-sized, 10 to 50 mm. in diameter, frequently scattered or the central portions falling away, olivaceous-green and blackening, usually somewhat lighter below, the upper surface becoming covered with granules of the same color as itself, the lobes rounded or somewhat irregular, with entire, undulate or crenulate and more or less crisped margins, frequently becoming somewhat elongated, ascending or suberect; attachment of thallus much as in the last, or more of the lower surface adhering to the substratum; algal cells somewhat more numerous toward the upper side; apothecia usually few and scattered, small, 0.5 to 1 mm. in diameter, sessile, the disk brown and darkening, flat or concave, the thalloid margin entire; hypothecium brownish; hymenium pale or pale brownish below and brownish above; paraphyses simple or rarely branched, frequently enlarged and brownish toward the apex; asci clavate; spores hyaline or pale, ellipsoid, 4-celled and becoming muriform, 18 to 26 μ long and 8 to 12 μ wide.

Collected twice along the north shore of Lake Superior and in several places in the southwestern portion of the State. The material from the Lake Superior region has smaller, more erect lobes, more numerous apothecia, and narrower spores. However, it agrees well with some of Arnold's European material. On various rocks.



LEPTOGIUM TREMELLOIDES (L.) S. F. GRAY.

In the United States southward to Maryland and westward to Iowa. Also known in Canada. Found also in Europe and Africa.

7. *Collema pustulatum* Ach. Syn. Lich. 317. 1814.

Thallus suborbicular or irregular and scattered, small, scarcely exceeding 10 to 18 mm. in diameter in ours, the lobes becoming long and narrow and subdichotomously many-cleft or more irregularly divided, or even shorter and subentire, frequently ascending or suberect; more closely attached portions of the thallus usually dying and leaving the commonly ascending lobes separately attached to the substratum, thus giving the scattered appearance, the rhizoids few; in color, brownish olivaceous or darker, and scarcely lighter beneath; algal cells somewhat more numerous toward the surfaces, especially the upper in the closely adnate portions; apothecia small and appearing like pustules on the thallus-lobes, 0.2 to 0.7 mm. in diameter, immersed or adnate, the disk brown, reddish or darkening, flat or concave, frequently deeply sunken in the entire thalloid margin; hypothecium pale; hymenium pale below and brownish above; paraphyses simple or rarely branched, commonly enlarged and brownish toward the apex; asci clavate; spores ovoid-ellipsoid, hyaline or pale, 4-celled and becoming muriform, 13 to 24 μ long and 10 to 13 μ wide.

Collected on calcareous rocks at Mankato.

Known from such rocks in Pennsylvania, Alabama, Illinois, and Iowa, and extending westward to the Pacific coast in British America. A strictly North American plant.

LEPTOGIUM Ach.; S. F. Gray, Nat. Arr. Brit. Pl. 1: 400. 1821.

PLATE 22.

The thallus is foliose and commonly orbicular, macroscopically appearing quite similar to that of *Collema*, but differing microscopically in that there is a cortex. This structure commonly consists of a single layer of cells, both above and below. The cortex makes the thallus somewhat more rigid than that of *Collema*, and renders the plants as a whole less gelatinous. In some of the species there is a rather poorly defined algal layer just below the upper cortex and somewhat of a medullary layer below this, but as a rule these layers can not be distinguished, though the algal chains are quite commonly more numerous toward the upper surface. These chains are hardly so long as in the last two genera. Rhizoids are rare, though clusters of simple ones may be found occasionally in any species at points where the thallus is closely attached. The thallus is partly attached by them, but for the most part simply adheres directly to the substratum. A single species, however, has numerous well-developed rhizoids, and this is sometimes separated from the genus.

The apothecia are quite common in some of the species, but seldom seen in others. The exciple is typically thalloid, but the algal cells may rarely disappear; or the exciple itself more rarely may be overgrown by the expanding disk and the whole structure of the apothecium become essentially biatoroid. The color of the disk is commonly some shade of brown, and it is usually flat or concave. The hypothecium, hymenium, and paraphyses are all much as in *Collema*. The spores of the species here admitted to the genus are pale and more or less muriform. Tuckerman admits plants having less highly developed spores, but his genus should doubtless be divided as it has been by some other authors.

The close relation of the present genus to *Collema* is apparent. The structure is somewhat higher in *Leptogium*.

Seven forms have been noted in the State. The habitats are similar to those of *Collemas*, but as a whole the plants are less confined to moist places.

Type species *Leptogium tremelloides* (L.) S. F. Gray, loc. cit.

EXPLANATION OF PLATE 22.—Fig. 1, a plant showing the thallus and the apothecia. Fig. 2, a portion of a thallus lobe with two apothecia. Fig. 3, a section of an apothecium and the thallus below; *a*, the hymenium, *b* and *c*, the hypothecium; *d*, the inner thallus with hyphæ and algal cells; *e*, the lower cortex, thickened below the apothecium. Fig. 4, a section of the thallus; *a*, the upper cortex; *b*, the hyphæ and algal cells; *c*, the lower cortex. Fig. 5, a paraphysis and an ascus. Fig. 6, free muriform spores. Fig. 7, algal filaments. Fig. 1, natural size; fig. 2, enlarged about 5 diameters; figs. 3, 4, enlarged 400 diameters; figs. 5, 6, 7, enlarged 650 diameters. From Schneider.

KEY TO THE SPECIES.

Rhizoids conspicuous.

- Lobes wide, rhizoids making a delicate nap..... 5. *L. myochroum*.
 Lobes narrower, rhizoids making a velvety nap..... 5a. *L. myochroum tomentosum*.

Rhizoids not noticeable except under the microscope.

Margins jagged and fringed.

- Lobes small and densely crowded, ascending and expanded toward the ends..... 1a. *L. lacerum pulvinatum*.

- Lobes as above except larger and less crowded..... 1. *L. lacerum*.

Margins undulate, lacerate, or isidioid, but not jagged and fringed.

- Upper surface not isidioid or lobulate; margins undulate, but neither isidioid nor lobulate..... 2. *L. pulchellum*.

Upper surface more or less isidioid granulate or lobulate.

- Thallus lead-colored above, frequently lighter below..... 3. *L. tremelloides*.

- Thallus dark lead-colored to greenish or olivaceous above, scarcely differing below..... 4. *L. chlorometum*.

1. **Leptogium lacerum** (Retz.) S. F. Gray, Nat. Arr. Brit. Pl. 1: 401. 1821.

Lichen lacer Retz. Fl. Scand. Prodr. 228. 1774.

Thallus closely adnate, more or less orbicular, middle-sized, 15 to 70 mm. in diameter, reticulately wrinkled, the many lobes ascending and obscuring the horizontal portions, expanded toward the ends, there sinuate and commonly divided into finely jagged and fringed margins, olivaceous-brown or more commonly lead-colored, scarcely lighter below, for the most part without rhizoids, the thallus adhering directly to the substratum; algal cells scattered throughout the thallus, but more numerous toward the top, so that algal and medullary layers are not distinctly differentiated; apothecia rather rare, small, 0.3 to 1.5 mm. in diameter, subsessile, the disk reddish brown and concave or flat, the margin thalloid, but the algal cells frequently disappearing, giving a biatoroid appearance, paler and entire; hypothecium pale; hymenium pale below and brownish above; paraphyses simple or rarely branched, commonly enlarged and brownish toward the apex; asci clavate; spores pale, ellipsoid, muriformly many-celled, 27 to 48 μ long and 11 to 19 μ wide.

Generally distributed over the State. On rocks among mosses.

The plant is widely distributed in North America. Known also in South America, Europe, and Africa.

1a. **Leptogium lacerum pulvinatum** (Hoffm.) Nyl. Syn. Lich. 1: 122. 1858.

Collema pulvinatum Hoffm. Deutsch. Fl. 2: 104. 1795.

Thallus brownish, smaller, and composed of densely crowded and smaller lobes with finely fringed edges, giving the plant a more pulvinate appearance than usual. Even more seldom fruited than the species.

A single collection was made along the shores of Snowbank Lake. On humus, mosses, and dead pine leaves. Ours is finely fruited.

Tuckerman considered the North American plants to belong to the present subspecies or to *Leptogium lacerum lophaeum* (Ach.) Nyl.^a Possibly the last named subspecies, also a small form with long ciliate dissected lobes, may exist in the State.

Both subspecies are recognized in Europe and Africa.

2. *Leptogium pulchellum* (Ach.) Nyl. Syn. Lich. 1: 123. 1858.

Collema pulchellum Ach. Syn. Lich. 321. 1814.

Thallus suborbicular, middle-sized to large, 5 to 12.5 cm. in diameter, closely adnate, but the marginal lobes commonly free and more or less raised, as are frequently some of the more central ones also, the upper surface thrown into delicate plicate wrinkles, and the lower surface more or less pitted and similarly wrinkled, the lobes somewhat imbricated, rounded with entire or slightly undulate margins; commonly lead-colored above, lighter-colored beneath, for most part adhering directly to the substratum, the rhizoids few and, as in other species, only to be seen in sections; algal chains more numerous toward the top, but quite numerous toward the lower side also, the central portions having few algal cells and representing a more or less distinct medullary layer; apothecia small to middle-sized, frequently subpedicellate, 0.7 to 2 mm. in diameter, the exciple thalloid with usually entire margin, the disk commonly flat; hypothecium brownish; hymenium pale below and brownish above; paraphyses simple or rarely branched; asci clavate; spores pale, becoming more or less muriform, ellipsoid, 18 to 30 μ long and 9 to 16 μ wide.

Collected in widely separate portions of the State and no doubt generally distributed, though rare. On trees and once on rocks.

Doubtless generally distributed over North America, except in arctic regions; little known, however, in the West. A strictly American plant. Known also in South America.

3. *Leptogium tremelloides* (L.) S. F. Gray, Nat. Arr. Brit. Pl. 2: 400. 1821.

PLATE 22.

Lichen tremelloides L. f. Suppl. Pl. 450. 1781.

Thallus suborbicular, middle-sized, 30 to 75 mm. in diameter, rather less closely adnate than that of the last and somewhat thinner, the lobes more or less imbricated, smooth, of somewhat similar form, but smaller, with commonly more ascending and entire margins, but sometimes finely dentate or undulate, crisped and irregular; beset more or less with isidioid granules, which may pass into minute lobules, lead-colored, frequently somewhat lighter below; rhizoids very rare and only seen in sections; algal chains more numerous toward the upper surface, but a medullary region scarcely to be distinguished in the thin thallus; apothecia sessile or subpedicellate, somewhat smaller than in the last, 0.5 to 1.7 mm. in diameter, the disk brown and flat, or somewhat convex and sometimes overgrowing the entire or irregular thalloid margin; hypothecium commonly pale; hymenium pale throughout or brownish above; paraphyses simple or very rarely branched, frequently enlarged and brownish toward the apex; asci clavate; spores pale, ovoid-ellipsoid, becoming muriformly many-celled, 18 to 27 μ long and 8 to 12 μ wide.

Throughout the northern portion of the State, extending as far south as Taylors Falls. Commonly on rocks.

Throughout the portion of North America east of the western Cordilleras and also in Alaska. There are several subspecies, and one or more forms are known in all of the grand divisions.

4. *Leptogium chloromelum* (Sw.) Nyl. Syn. Lich. 1: 128. 1858.

Lichen chloromelos Sw. Fl. Ind. Occ. 3: 1892. 1806.

^aSyn. Lich. 1: 122. 1858.

Thallus thin, suborbicular or irregular and frequently more or less scattered, rather small, 25 to 60 mm. in diameter, or the scattered lobes extending over larger areas, becoming densely isidioid-granulate, the lobes more or less imbricate and ascending with crisped, undulate, or lacerate margins, or the margins produced into isidioid lobules, the marginal lobes, in the more continuous forms, somewhat more expanded; lead-colored, varying toward greenish or olivaceous, scarcely differing in color below; rhizoids and attachment of thallus as in the last; algal chains not so distinctly more numerous toward the top, and medullary and algal layers rather less distinct than in any of the above species; apothecia small in ours, 0.5 to 1 mm. in diameter, sessile, the disk brown and flat, the margin thalloid in structure, granulate, irregular, or more rarely entire; hypothecium pale; hymenium pale below and brownish above; paraphyses simple or rarely branched, frequently thickened and brownish toward the apex; asci clavate; spores ovoid to ellipsoid-pointed, pale, becoming muriformly many-celled, 15 to 32 μ long and 8 to 13 μ wide.

Collected at Taylors Falls and at Mankato. On sandstone. Perhaps most of ours should be referred to subspecies *conchatum* Tuck.^a

North American range scarcely differing from that of the last foregoing. Also quite as various in form as the last and known in some form in all of the grand divisions.

5. *Leptogium myochroum* (Schrad.) Tuck. Gen. Lich. 99. 1872.

Lichen myochrous Schrad. Journ. Bot. 1799¹: 18. 1799.

Thallus suborbicular, or irregular, somewhat closely attached to the substratum, small, and only slightly lobed or becoming larger and more lobed, 25 to 80 mm. in diameter, the lobes more or less ascending and imbricated, wide, rounded, subentire, undulate; lead-colored varying toward olivaceous or blackish, smooth or more or less rugose, somewhat granulate, clothed below with whitish rhizoids, composing a delicate nap; algal chains more numerous toward the top, a fairly well-developed medullary layer below, though containing scattered algal chains; apothecia middle-sized, 1 to 2 mm. in diameter, subsessile, the disk flat and reddish brown, the margin thalloid and more or less irregular and granulate; spores pale, ellipsoid, becoming somewhat muriform, 23 to 30 μ long and 7 to 9 μ wide.

Ours sterile, and the spore and apothecial characters taken from Tuckerman. Frequently excluded from the present genus.

Generally distributed over the State. On trees and rarely on rocks.

The plant is generally distributed over North America. Known also in Europe.

5a. *Leptogium myochroum tomentosum* (Hoffm.) Schaer. Lich. Helv. Spic. 534. 1842.

Collema tomentosum Hoffm. Deutsch. Fl. 2: 99. 1795.

Thinner, darker, usually narrower-lobed, more imbricated and having sinuate margins, velvety below.

The lobes tend to be normal in ours, however, and perhaps our plants should not be referred to the subspecies.

Collected on Carlton Peak and along the international boundary from Harding to Warroad. On trees.

Elsewhere in North America known only in the Rocky Mountains and Alaska. Known also in Europe

Family PYRENOPSISIDACEAE.

This family is a small one, represented in our flora by only two genera and a few species. The thallus is crustose or foliose, or may even exhibit a fruticose tendency as in the *Omphalarias*. A cellular cortex is present in *Pyrenopsis*, but not in *Omp*-

^aSyn. N. A. Lich. 1: 163. 1881.

laria, which is quite gelatinous when wet. The algal symbiont is Gloeocapsa-like, and the gelatinous nature of the Omphalarias is due to the sheath of the cells or the colonies. There is an obscure differentiation into algal and medullary layers in the Omphalarias.

The apothecia are usually immersed and contain the simple or 2-celled spores, which are quite similar in the two genera and suggest a close relationship of their members, though these are quite different externally.

The family is somewhat closely related to the Collemaceae, and the relationship with the Pannariaceae is perhaps closer.

PYRENOPSIS Nyl. Mém. Soc. Sci. Nat. Cherb. 5: 143. 1857.

The thallus is crustose-conglomerate or with ascending coralloid branchlets. The whole structure is obscure and devoid of definite layers. However, in ours at least, a parenchymatous structure may be made out, which extends throughout, at least in the ascending branchlets. The algal symbiont consists of blue-green cells, occurring in clusters, varying considerably in size and number in a cluster and the individual cells not differing greatly from those of Omphalaria. The plants are obscure, and when conspicuous enough to attract notice, they may easily be overlooked as so much dirt on the rocks, or if noted as lichens, passed over as some one of the darker and more obscure Pannarias. The apothecia in ours are usually quite open-discoid, and yet they are rather rare, adnate or immersed, small and very difficult to distinguish when present. A thalloid exciple is present. The hymenium and the hypothecium are both more or less brownish. The paraphyses are usually simple and rather slender, but not seldom more or less gelatinized and indistinct. The spores are almost constantly simple.

Nylander recognizes *Synalissa* Fr.^a as a separate genus, somewhat below the present one in that the thallus is scarcely cellular and the apothecia are more inclined to be immersed. He admits to his lower genus, however, at least one form having a cellular thallus. Tuckerman admits all these species to the present genus and also certain species having the algal cells in chains. Much work will be required before the questions involved can be settled, but our three species may certainly be placed in a single genus. Again, while there is yet much doubt regarding the relationship of some of the species usually assigned to the present genus and *Synalissa*, it appears to be certain enough that ours are more closely related to *Pannaria* than to *Collema*, and are yet nearer to *Omphalaria*.

Three species occur in the State. On rocks.

Type species *Pyrenopsis fuscatula* Nyl. loc. cit.

KEY TO THE SPECIES.

- Thallus olivaceous, granulose; spores 8 to 11 μ long and 5 to 6 μ wide..... 1. *P. melambola*.
 Thallus blackish, granulose.
 Spores 10 to 20 μ long and 7 to 9 μ wide, sometimes 2-celled. 2. *P. phaeococca*.
 Spores 12 to 13 μ long and 6 to 8 μ wide..... 3. *P. polycocca*.

1. **Pyrenopsis melambola** Tuck. Syn. N. A. Lich. 1: 136. 1882.

Synalissa melambola Tuck. Proc. Amer. Acad. 12: 170. 1877.

Thallus of minute olivaceous granules, compacted into finally thick and substipitate scabrous, black areoles, these reaching 1 mm. in diameter and forming a close crust; apothecia minute, 0.2 to 0.4 mm. in diameter, 1 to 6 in each areole, immersed, the disk black, the margin thalloid, persistent, and of the same color as the disk; hypothecium pale brownish; hymenium usually pale below and pale brownish

^aSyst. Orb. Veg. 1: 297. 1825.

above; paraphyses gelatinized and indistinct; asci clavate; spores simple, ellipsoid, 8 to 11 μ long and 5 to 6 μ wide, thus somewhat larger than according to Tuckerman's measurements, as are also the apothecia.

A single collection was made on a boulder at Mankato in 1899. Forms of *Pyrenopsis* have been noted frequently in various portions of the State, but in the absence of fruit it has been impossible, except in this instance and the ones below, to refer the specimens to species with any degree of certainty.

A North American plant, previously only known in the original locality in Alabama.

2. *Pyrenopsis phaeococca* Tuck. Syn. N. A. Lich. 1: 136. 1882.

Synalissa phaeococca Tuck. Gen. Lich. 80. 1872.

Thallus of blackish, scarcely coralloid granules, which form an areolate crust; the areoles of about the same size as those of the last, rarely reaching 1 mm. in diameter; apothecia somewhat larger than in the last, 0.2 to 0.5 mm. in diameter, adnate or immersed, 1 to 3 in each areole, the disk evident and concave in ours, black with a margin of the same color, hypothecium pale brown; hymenium pale below and brownish above; paraphyses simple, frequently thickened and brownish toward the apex; asci clavate; spores simple or rarely 2-celled, ovoid-ellipsoid, 10 to 20 μ long and 7 to 9 μ wide. The algal cells are few in each cluster, and in this and other points, as the color, the plant seems quite as near the next, though the spores agree better here.

A collection was made at Mankato in 1899 and another at Grand Marais in 1902. On boulders.

A North American lichen, previously known in North Carolina, Massachusetts, and New Hampshire. The other plant which our specimen resembles is also confined to our grand division, having been collected in Vermont.

3. *Pyrenopsis polycocca* (Nyl.) Tuck. Syn. N. A. Lich. 1: 136. 1882. PLATE 23, A.

Synalissa polycocca Nyl. Syn. Lich. 1: 96. 1858.

Thallus of blackish granules, which pass into a more or less areolate crust, the areoles of the same size as those of the last or smaller and for the most part absent when the thallus is continuously granulose; apothecia rather numerous, sometimes a dozen or more in a single areole and almost completely obscuring the thallus, minute, 0.1 to 0.3 mm. in diameter, of the same color as the thallus, globose, with a punctiform or slightly open and urceolate disk; hypothecium pale or pale brownish; hymenium pale below and brownish above; paraphyses more or less coherent and indistinct; asci cylindrico-clavate; spores ellipsoid, simple, 12 to 13 μ long and 6 to 8 μ wide.

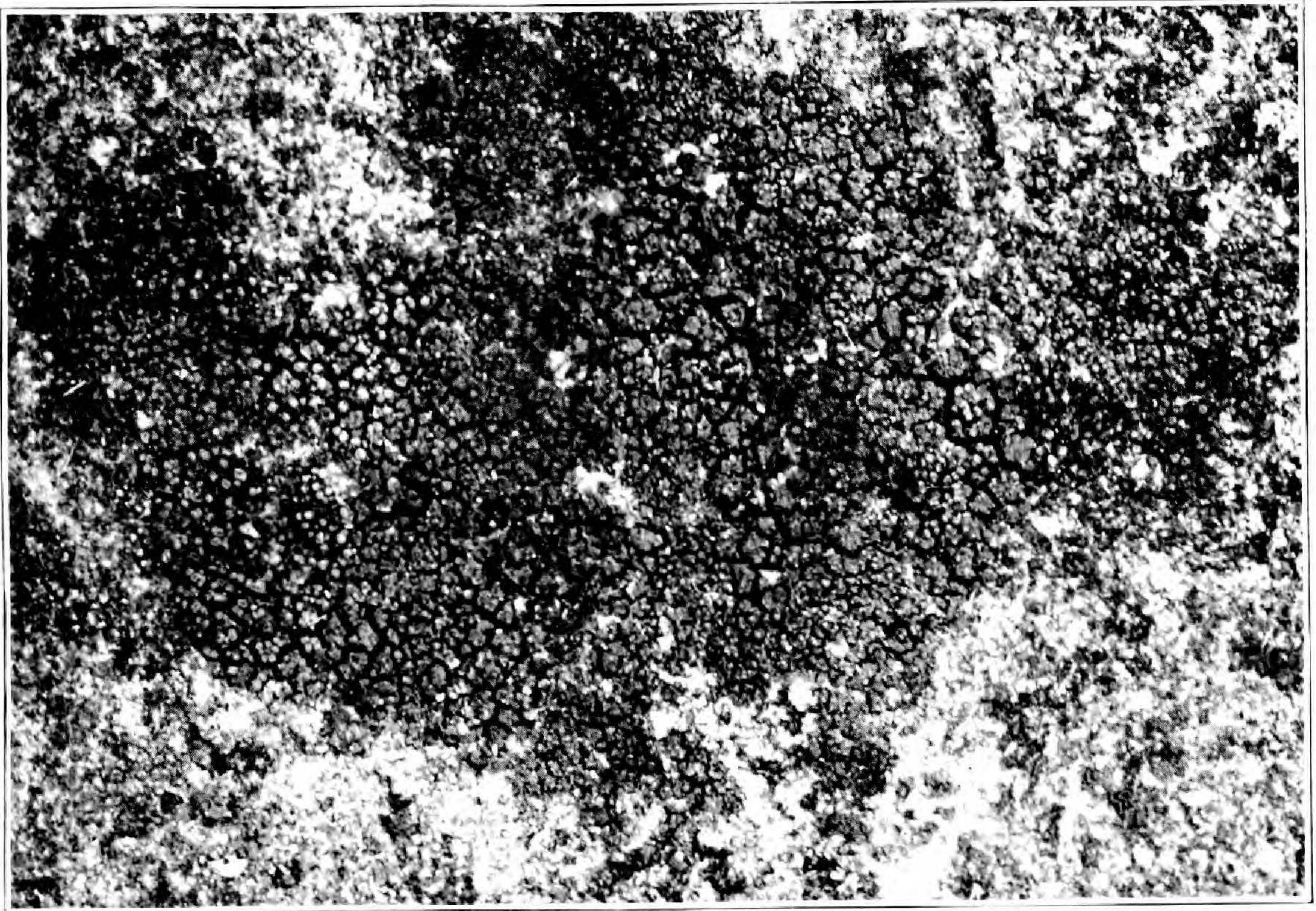
Collected on rocks along the shore of Lake Superior at Grand Marais.

A North American plant, previously reported from Vermont.

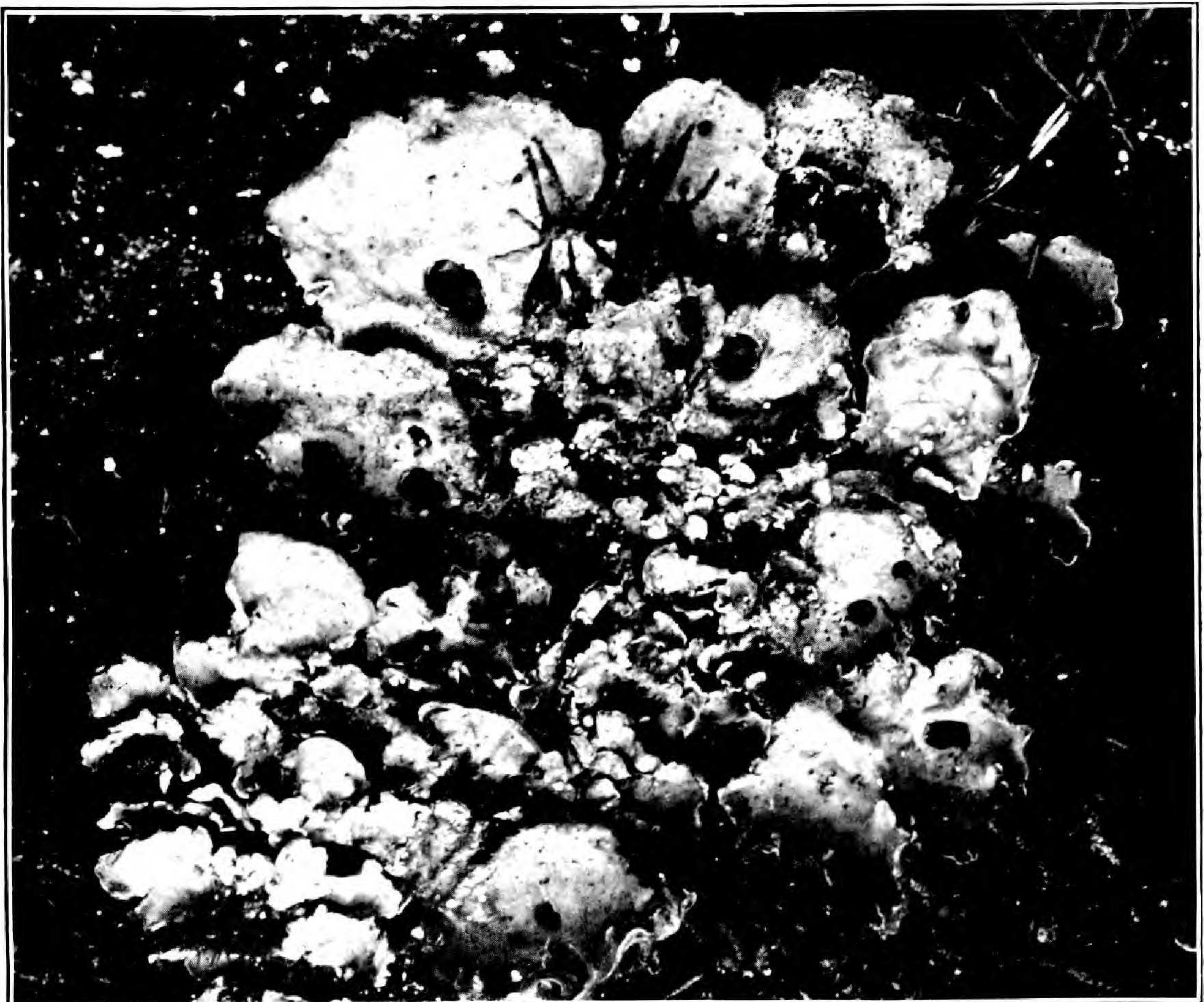
EXPLANATION OF PLATE 23.—A, Plant of *Pyrenopsis polycocca* on rocks, showing the granulate and somewhat areolate thallus. B, Plant of *Solorina saccata* on rocks, showing the foliose thallus and the immersed apothecia. A enlarged about 3 diameters; B, about 2½ diameters.

OMPHALARIA Dun. & Gir. in Dur. Fl. Algér. 1: 200. pl. 18. f. 4, 5. 1846.

The thallus is neither strictly fruticose nor yet in most instances foliose. It is commonly small and somewhat raised from the substratum, exhibiting thus at least a fruticose tendency, and is attached to the substratum at a single point. There is no cellular cortex, but there is an outer gelatinous layer composed of gelatinized hyphæ and walls of dead algal cells. Within or below this is an algal layer, consisting of the algal cells and hyphal branches. The central portions of the thallus, or in the more foliose forms the lower part, is frequently differentiated as a more or less distinct medullary layer. The algal cells, in all of ours at least, occur in groups, these varying considerably in number of cells in each, and each cell of a group having its own wall. Yet, in any of the species, the cells may sometimes occur singly. On the



A. PYRENOPSIS POLYCOCCA (NYL.) TUCK.



B. SOLORINA SACCATA (L.) ACH.

whole, these algal symbionts seem to be a form of *Gloeocapsa*. In some species found in North America and referred to the present genus the algal cells occur in chains. These we have not studied carefully, but they should perhaps be referred to another genus. The thallus as a whole may be merely an irregular or even somewhat rounded mass, or it may be somewhat or even decidedly branched. The color is usually a dull black, and the thallus reminds one somewhat of that of certain *Collemas*.

The apothecia are very small, subglobose and immersed, or more rarely becoming superficial and more or less disk-shaped. They are either terminal on the lobes or variously scattered over the thallus. The hypothecium and the hymenium vary from colorless to brown. The paraphyses are more or less coherent and indistinct, but seem to be uniformly simple. In the material examined, the asci scarcely showed apical thickening. In the species admitted here, the spores are hyaline and are simple, though plants having 2-celled spores have usually been admitted to the genus.

Notwithstanding the peculiarity of the present genus as regards the algal symbiont, it shows an apparently close relationship with *Senechoblastus* and a somewhat more remote one, when the spores are considered, with *Collema*. Yet, doubtless, all considered, the relationship is closer with *Pyrenopsis* or *Lichnia*.

Three species have been determined from the rocks of the State. Other sterile forms have been collected.

Type species *Omphalaria nummularia* (Duf.) Dur. & Mont. loc. cit.

KEY TO THE SPECIES.

- Thallus scarcely or only slightly lobed; plants small..... 1. *O. minnesotensis*.
 Thallus plainly lobed; plants larger.
 Lobes strongly ascendant..... 2. *O. pulvinata*.
 Lobes shorter and only slightly raised..... 3. *O. phyllisca*.

1. *Omphalaria minnesotensis* sp. nov.

Thallus adnate or somewhat raised from the substratum, irregular in form or rarely rounded, very small, 0.5 to 2 mm. in diameter, above smooth or more commonly uneven; lobes absent or short and irregular, black and rigid; algal cells in clusters; apothecia immersed and minute, scarcely exceeding 0.3 to 0.5 mm. in diameter, globose with a punctiform disk, often in plainly raised pustules, one to several in each plant; hypothecium pale or slightly colored; hymenium pale; paraphyses more or less coherent, gelatinous and indistinct; asci cylindrico-clavate and variously irregular; spores minute and numerous in each ascus, subspherical to ellipsoid, 3 to 6 μ long and 2 to 3 μ wide.

On calcareous rocks at Minneapolis.

2. *Omphalaria pulvinata* (Schaer.) Nyl. Ach. Soc. Linn. Bord. 21: 265. 1856.

Collema stygium pulvinatum Schaer. Enum. Lich. Eur. 260. 1850.

Thallus pulvinately lobed, the lobes ascendant or suberect, giving the thallus a fruticose tendency, but also with a basal horizontal and strictly foliose portion, predominating in younger and less developed states and giving character to the whole structure; black in color, the lobes more or less divided and having variously irregular margins; apothecia minute, scarcely exceeding 0.6 mm. in diameter, sometimes becoming prominent and tuberculate, said to be pallescent (Nylander), though this has not been observed in ours, more commonly along the margins of the lobes; hypothecium pale or pale brownish; hymenium pale below and pale brownish above; paraphyses simple, more or less gelatinized and coherent; asci clavate; spores short-ellipsoid, 9 to 12 μ long and 5 to 7 μ wide.

Collected once in the State. On calcareous rocks at Mankato.

Previously known from New England, New York, Iowa, Nebraska, and Colorado. But Tuckerman seems not to have seen the apothecia, which are common enough in ours and in the Iowa plant. Known also in Europe and Africa.

3. *Omphalaria phyllisca* (Wahl.) Tuck. Gen. Lich. 84. 1872.

Endocarpon phylliscum Wahl. in Ach. Meth. Lich. Suppl. 25. 1803.

Thallus strictly foliose, or sometimes showing a slightly fruticose tendency, only slightly raised from the substratum and presenting above a lobulate, rosulate, flattened surface with the marginal lobes better developed, rarely somewhat imbricated, black and rigid, small, 1.5 to 3 mm. in diameter in ours, scarcely so gelatinous as the other two species; algal cells unusually large and frequently solitary, 10 to 28 μ in diameter; apothecia minute, scarcely exceeding 0.5 mm. in diameter, immersed-globose with a punctiform disk, the whole structure appearing as minute slightly raised pustules scattered over the upper surface of the thallus; hypothecium pale or pale brownish; hymenium pale; paraphyses simple, but becoming gelatinized and indistinct; asci cylindrical to fusiform; spores shortly oblong-ellipsoid, 6 to 10 μ long and 4 to 5 μ wide, 8 to 16 in each ascus.

A single collection was made at Grand Marais. On the face of a perpendicular bluff near the shore of Lake Superior.

Previously collected in North America in New England, Oregon, and along the north shore of Lake Superior in Canada. Known also in Europe.

The plant reported as this species from Redwood Falls is not the same, and a plant similar to the latter was collected at Grand Portage. The spore characters of these two plants were not shown distinctly in the final examination, and they can not be definitely located for the present. Our plants also resemble strongly *Omphalaria pyrenoides* Tuck. from New Mexico.

Family EPHEBACEAE.

The family is represented in our flora by a single genus with one or two species. So far as these two species with the same algal symbiont, *Sirosiphon*, are concerned, the family is perfectly distinct. But there are a number of other forms with different algal symbionts which are frequently placed near *Ephebe*, and which might, if considered, invalidate the distinct definition of the family. One of these is *Lichnia*, a rare North American lichen genus, and another is what we have placed in the next family under the name *Pannaria nigra*.

The whole form of the plants is determined by the algal symbiont^a in our representatives of the family, this alga having a fruticose habit. The other characteristics of thallus and apothecia are sufficiently discussed under the single genus below.

The relationship of the present family with the *Pannariaceae* is apparent, especially through *Pannaria nigra*. The relationship is hardly to be regarded as a close one, however, when we consider that even in this species of *Pannaria* there is parenchymatous tissue throughout and the form of the thallus is determined by the fungal symbiont.

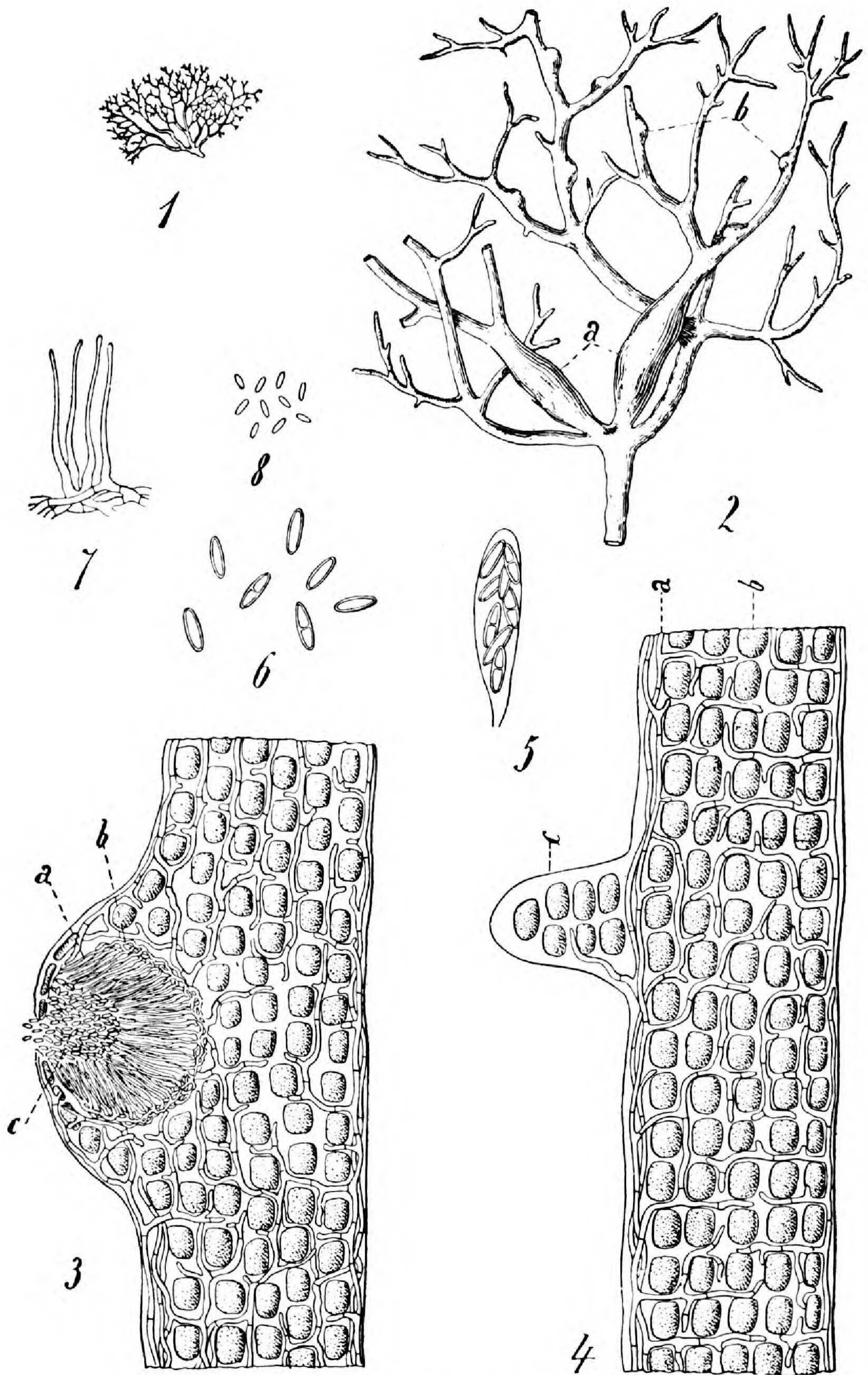
The *Ephebaceae* are lower than the *Pannariaceae*, both as to thallus structure and as to apothecial and spore characters, but the present family scarcely stands between the last two families and the *Pannariaceae*.

EPHEBE Fr. Syst. Orb. Veg. 1: 256. 1825.

PLATE 24.

The thallus is peculiar in structure and wholly different from that of any other Minnesota lichen genus. The form is entirely determined by the algal symbiont,^a which is the blue-green filamentous alga *Sirosiphon*. This gives us a brownish or blackish branched fruticose thallus of small size and not differing macroscopically from the free alga, which grows on the same moist rocks as the lichen. Hence every specimen must be carefully studied microscopically to ascertain whether the lich-

^a See footnote, p. 23.



EPHEBE PUBESCENS (L.) FR.

enoid symbiotic condition exists or not. If the fungal hyphæ are present, they are found to extend in a longitudinal direction between the algal cells or just beneath the outer algal sheath. As has been observed by Schwendener, in some of our specimens there is a parenchymatous cellular structure toward the basal older portions of some of the thalli. This is not a cortex, but extends throughout the whole diameter of the filament. In these same filaments the hyphal threads may usually be detected toward the ends of the filaments. The hyphæ may be few or many, and enlargements often occur here and there on the thalli from which hyphæ protrude in dense clusters. These enlargements may give rise to apothecia or the so-called spermagonia, but we have been unable thus far to detect any such structures in any specimens examined. Possibly certain structures examined were old spermagonia that had discharged their spermatia.

The apothecia are minute, immersed in the thallus, or becoming superficial and globose-diskoid. The spores are hyaline, oblong or ellipsoid, simple or 2-celled. As indicated above, none have yet been found in any of our specimens.

Of our lichens the present genus is evidently most closely related to *Pannaria*, though here the relation scarcely seems to be a very close one. *Pannaria nigra* appears somewhat similar under a hand lens, though not so microscopically. Probably *Lichnia*, thus far not noted in Minnesota, is more closely related.

Two species have been reported from the State, but one of these, in the absence of fruit in the specimen, must be regarded as doubtful. The plants occur on rocks.

Type species *Lichen pubescens* L. Sp. Pl. 1155. 1753. (*Ephebe pubescens* (L.) Fr.)

EXPLANATION OF PLATE 24.—Fig. 1, the plant. Fig. 2, *a*, position of apothecia; *b*, spermagonia. Fig. 3, a section of a branch and a spermagonium; *a*, sterigmata; *b*, the inclosing hyphæ; *c*, the spermatia. Fig. 4, a section of the thallus; *a*, fungal hyphæ; *b*, algal cells; *c*, a young branch. Fig. 5, an ascus. Fig. 6, free spores. Fig. 7, sterigmata. Fig. 8, spermatia. Fig. 1, natural size; fig. 2, enlarged about 4 diameters; figs. 3, 4, 7, enlarged 400 diameters; figs. 5, 6, 8, enlarged 650 diameters. From Schneider, except 5 and 6, which are from Crombie.

***Ephebe pubescens* (L.) Fr.** in Nyl. Syn. Lich. 1: 90. 1858. PLATES 20, B, 24.

Lichen pubescens L. Sp. Pl. 1153. 1853.

Thallus much branched, rather rigid, the branching subdichotomous, the branches subcylindrical, somewhat spreading and variously tangled; usually blackish brown but sometimes olivaceous, the whole plant 3 to 25 or possibly sometimes 30 mm. in length, the filaments sometimes reaching 0.75 to 1 mm. in diameter toward the rarely parenchymatous basal portions; apothecia immersed several together in swellings of the thallus, the disk punctiform; spores simple or 2-celled, oblong-ellipsoid, 11 to 16 μ long and 3 to 4 μ wide.

Frequent in the northern portion of the State, and once found as far south as New Ulm. On rocks and, if on horizontal ones, preferring depressions in which water stands after rains. Ours sterile and perhaps nearer *Ephebe solida* Born.^a

Throughout the eastern region bordering the Appalachian system of mountains and northward to Greenland. Also reported from Vancouver Island. Known also in Europe and northern Africa.

The material recorded in the preliminary reports as *Ephebe solida* seems nearer *E. mammillosum* (Lyngb.) Fr., but is sterile and too uncertain to record.

EXPLANATION OF PLATE 20.—See p. 135.

Family PANNARIACEAE.

The family as represented in our flora contains three genera, in which the thallus is certainly higher than in any of the closely related families immediately preceding, and at the same time quite different in external appearance from the forms of thalli in the two closely related families next following. However, there is no escape

^a Ann. Sci. Nat. Bot. III. 18: 169. 1852.

from some uncertainty in any limitations that may be set to families in these closely related lichens, and Schneider includes the last family, the present one, and the next two all in the Pannariaceae.

Except for the Omphalarias, the lichens of the last three families have shown no differentiation into algal and medullary layers, and we prefer to exclude from the present family *Ephebe* with its rudimentary thallus. Likewise it seems at least conducive to clearness to separate the three genera of the present family from the much larger and more plainly foliose, lobed, and otherwise different thalli of the members of the next two families.

The algal symbiont is always a blue-green alga, most commonly *Polycoccus*. The thallus is small, but foliose or foliose-squamulose, and upper and lower cortices are always present. The apothecia are immersed or superficial. The spores vary from simple and minute in the first genus to 4-celled in some of the species admitted to the last genus. Thus as regards spore characters, the present family is hardly so high as the Collemaceae, but the spores of lichens are in all probability often degenerate, and greater spore degeneration may be expected frequently in forms otherwise higher.

ENDOCARPISCUM Nyl. Flora 47: 487. 1864.

The thallus is plainly foliose and usually not so closely attached to the substratum as that of *Heppia*. Indeed, the whole external appearance of the thallus is quite like that of *Dermatocarpon*, and one would very naturally pass over either of our species as members of that genus; for the fact of the apothecia being commonly immersed points toward *Dermatocarpon* quite as much as does the general appearance. There is a good cortex on both sides, but the development is on the whole better on the lower side. The medullary layer is commonly well developed, though scarcely so in one of the species here admitted to the genus. The algal layer is also well represented, the algæ extending well upward into the upper cellular area and obscuring the cellular structure. The algal cells are blue-green, but scarcely more than half as large as those of *Heppia*, with which genus the present one is frequently placed.

The apothecia are commonly sunken into the thallus and usually indicated by an ostiole, though they may even become superficial and disk-like and have a thalloid exciple. The spores are simple, hyaline, minute, and numerous in the asci.

The superficial resemblance of the present genus to *Dermatocarpon* has already been noted, and the species are sometimes included in that genus. However, the propriety of including in a single genus forms having very different algal symbionts is uncertain. On the other hand, there seems to be a somewhat close resemblance between *Endocarpiscum* and *Heppia*, though as regards the algal symbiont the relation is rather with *Sticta* or *Pannaria*.

Two species have been noted for the State, the second of which we place in the present genus because of spore resemblance and apparent similarity of algal symbionts. Also as to thallus-structure this species is quite as much at home here as in the genus *Heppia*. On rocks or earth.

Type species *Endocarpiscum guepinii* (Moug.) Nyl. loc. cit.

KEY TO THE SPECIES.

- On rocks, thallus of moderate size and thickness. 1. *E. guepinii*.
On earth, thallus smaller and thinner. 2. *E. polysporum*.

1. **Endocarpiscum guepinii** (Del.) Nyl. Flora 47: 487. 1864.

Endocarpon guepinii Del.; DC. Bot. Gal. ed. 2. 2: 594. 1830.

Thallus foliose, thickened, commonly raised from the substratum toward the margins; ours rather thicker than foreign specimens at hand and not showing the serrate border common in other material; greenish or brownish olive, flat or in ours more commonly variously irregular above, below smooth or wrinkled and usually

lighter in color, attached to the substratum at a single point, the medullary layer well represented; small, 2.5 to 6 mm. in diameter; apothecia deeply sunken in minute pits, or becoming superficial and disk-shaped; spores rounded or oblong.

No mature fruit has been found, and the spore and apothecial characters taken from Tuckerman.

Collected on frequently wet rocks, at Morton, and reported as an Endocarpon.

Elsewhere in North America from Massachusetts, Maryland, Arkansas, and California. Known also in Europe and Australia.

2. *Endocarpiscum polysporum* (Tuck.) Fink.

Heppia polyspora Tuck. Syn. N. A. Lich. 1: 115. 1882.

Thallus foliose and closely attached to the substratum by means of numerous rhizoids, flat above or depressed with a raised margin, orbicular or irregular in form, small or very small, 1.5 to 4.5 mm. in diameter, smooth, olive-green or olivaceous, usually darker at the margin and below, the medullary layer represented by loosely arranged irregular cells, forming a tissue resembling the spongy parenchyma of leaves; apothecia immersed in the thallus, without thalloid exciple, the disk somewhat depressed and dark brown or black, very small, 0.2 to 0.5 mm. in diameter; hypothecium pale yellowish brown; hymenium pale below and yellowish brown above; paraphyses very slender, commonly simple, frequently enlarged and brownish toward the apex; asci cylindrical, varying toward clavate or ellipsoid; spores subspherical, 4 to 7 μ the longest way.

A few apothecia are larger, and the spores are also somewhat larger than Tuckerman's plant showed. Possibly the plant should be separated from the present genus, but it can scarcely be placed with *Heppia* as was attempted by Tuckerman.

Collected on earth at Granite Falls.

Tuckerman's plant was from Colorado. Nylander's *Heppia arenivaga* from Japan ^a appears to be the same plant.

Heppia polyspora of the preliminary reports.

HEPPIA Naeg. in Hepp. Spor. Flecht. Eur. pl. 7. f. 49. 1853.

The thallus is distinctly foliose and closely attached to the substratum by means of rhizoids, though often rising more or less at the margins. The structure is peculiar in that the thallus is cellular throughout. The cells of three or more layers above are elongated horizontally and correspond to the usual upper cortex. Below this the cells are rather loosely arranged and elongated vertically, those midway between the upper and lower surfaces being most elongated and replacing a medullary layer. The cells of the lower portion are again less elongated and correspond somewhat to a lower cortex. The algal cells are scattered throughout the whole region of vertically elongated cells and even extend into the cortical regions. The algæ are blue-green, but larger than those of *Solorina* and *Pannaria*. The cells are said to occur in chains, but this is difficult to make out. They are usually large, 14 to 22 μ long.

The apothecia are commonly immersed in the thallus, though in *Heppia despreauxii* they may be more or less raised. Tuckerman seems to have distinguished a thalloid exciple in certain raised apothecia of the above species, but such a structure is commonly absent. The hypothecium and hymenium are pale or slightly colored. The paraphyses are commonly simple and somewhat coherent. The spores are simple.

The resemblance of the present genus to *Solorina* in upper surface and disposition of apothecia, is not difficult of detection, but in the minute anatomy of the thallus we encounter very radical differences. The relation as to thallus is probably nearer to *Endocarpiscum*, though the algal cells are quite different.

A single species occurs in the State. On calcareous soil.

Type species *Heppia urceolata* Naeg. loc. cit.

^a Nyl. Lich. Jap. 104. 1890.

1. *Heppia despreauxii* (Mont.) Tuck. Gen. Lich. 46. 1872.

Solorina despreauxii Mont. in Webb & Berth. Hist. Nat. Canar. 3²: 104. 1840.

Thallus foliose or possibly to be considered squamulose, closely attached to the substratum by numerous rhizoids, orbicular with the edges sometimes raised and crenately lobed, very small, 1.5 to 4 mm. or possibly reaching 6 mm. in diameter, or frequently the thalli clustered into a continuous crust covering an area 20 to 30 mm. in diameter, smooth above or frequently somewhat rugulose, olive in color, varying toward green or black, usually pale below; apothecia frequently solitary in the small thalli, commonly immersed and depressed-urceolate, rarely even convex, the disk reddish brown, small or becoming larger and occupying nearly the whole thallus, 0.75 to 2.5 mm. in diameter; hypothecium pale to pale yellowish; hymenium pale below and yellowish above; paraphyses somewhat coherent, commonly simple, frequently thickened and brownish toward the apex; asci clavate to cylindrical; spores hyaline, oblong-ellipsoid, 17 to 26 μ long and 7 to 10 μ wide.

Collected on calcareous soil in widely separated portions of the State. No doubt occurring wherever such soil exists in Minnesota.

Widely distributed in the United States, but I do not find it recorded from British America. *Heppia virescens* (Despr.) Nyl., reported for North America, is the same, and probably also *Heppia terrena* Nyl. from California. Known also in Europe and Africa.

PANNARIA Del. in Bory, Dict. Class. Hist. Nat. 13: 20. 1828.

The thallus may be distinctly foliose, though more often small and squamulose. It is usually quite closely attached to the substratum by means of rhizoids, though often resting upon a more or less distinct hypothallus. Indeed, it is in the present genus that the so-called hypothallus finds its best expression. The thallus appears to be crustose in some species, but so far as we have examined there is more or less of a cellular cortex below as well as above. This is true of the Minnesota species at least. The upper cortex is well developed, thick, the cells large and distinct. The medullary and algal layers are distinct in the more strictly foliose forms, but in those approaching a squamulose condition there appears to be a parenchymatous structure throughout and algal cells scattered throughout, except in the outer cells of the cortex. In all of ours, the algal symbiont is a blue-green alga, probably *Polycoccus*, and the chains of cells can usually be seen readily enough. In color the thallus varies from sea-green to a dull black.

The apothecia are usually small and sessile or subsessile upon the thallus. The thalloid margin may be present or absent, sometimes even in a given species. The disk is usually more or less concave and varies in color from a reddish brown to a dull black. The hypothecium and the hymenium vary from pale to brown. The asci vary from clavate to cylindrical in form, and the pale or hyaline spores from simple to 4-celled.

Tuckerman has included in the genus forms having green algal cells, others having both green and blue-green, and others having blue-green only. Doubtless his genus *Pannaria* should be divided into at least four genera. However, excluding *Amphiloma*, all of our Minnesota species are forms having the blue-green algal cells. There is still a difficulty as to spore characters, but simple and 2-celled spores occur in one species and 2 and 4-celled spores in two others, so that a division on this basis alone would be somewhat arbitrary. On the other hand, the last three species present certain differences in thallus structure, and we may be committing a serious error in not recognizing the genus *Lecothecium* of Trevisan.

The genus is related somewhat closely to *Collema* and less closely to *Heppia* and *Peltigera*.

Seven forms occur in Minnesota. On trees, rocks, or earth.

Type species *Pannaria rubiginosa* (Thunb.) Del. loc. cit.

and 1 to 2 mm. long; color varying from ashy to brown, ours frequently light below where not darkened by the hypothallus; lower cortex absent or very poorly developed; apothecia adnate, the disk reddish brown and frequently convex, the thalloid margin crenate, frequently white-powdery and often disappearing, small, scarcely reaching 1 mm. in diameter in specimens seen; hypothecium pale or slightly brownish; hymenium pale below and brownish toward the top; asci clavate; paraphyses simple or rarely branched, commonly enlarged and brownish toward the apex; spores simple, hyaline, ellipsoid to ellipsoid-pointed, 16 to 22 μ long and 8 to 12 μ wide.

Generally distributed along the western international boundary as far east as Harding. On cedars in swamps and rarely on rocks.

Generally distributed throughout North America east of the Rocky Mountains. Found also in Africa.

EXPLANATION OF PLATE 25.—Plant on white cedar, showing the apothecia and the squamulose thallus. Enlarged $1\frac{1}{2}$ diameters.

3. *Pannaria microphylla* (Sw.) Mass. Ric. Lich: 112. f. 221. 1852.

Lichen microphyllus Sw. Vet. Akad. Handl. 301. 1791.

Thallus squamulose, closely adnate or the margins somewhat raised, the squamules more or less imbricated, rather thick, expanded or collected into a continuous crust, the margins sometimes rather obscurely crenate, smaller than those of the last above; sea-green varying to ashy or tawny-brownish, usually dark below, though the hypothallus is obscure or absent; lower cortex wanting or poorly developed; apothecia adnate, the disk pale brown or blackening, frequently convex, the thalloid margin crenate and often disappearing so that the apothecia become biatoroid, small, 0.5 to 1 mm. in diameter; hypothecium pale; hymenium colorless below and brownish above; asci clavate; paraphyses simple or rarely branched, commonly enlarged and brownish toward the apex; spores hyaline, simple, ellipsoid, 14 to 19 μ long and 5 to 7 μ wide.

Collected in several widely separate localities and doubtless generally distributed over the State. On all rocks except lime.

The plant is widely distributed in North America. Known in all the grand divisions except Australia.

4. *Pannaria lepidiota* (Sommerf.) Th. Fr. Nov. Act. Soc. Sci. Ups. III. 3: 174. 1861.

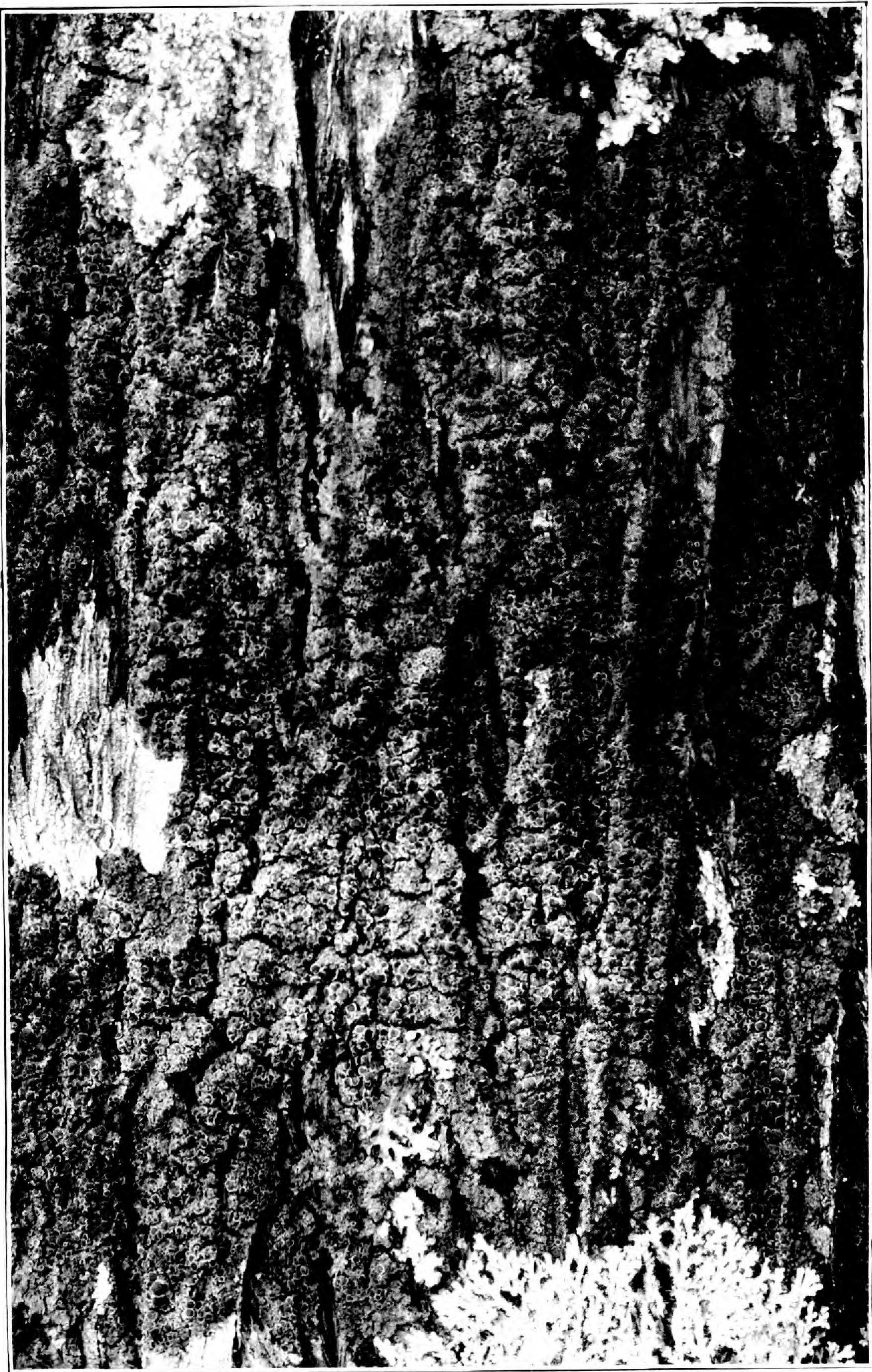
Lecidea carnosula lepidiota Sommerf. Suppl. Fl. Lapp. 174. 1826.

Thallus squamulose, the squamules larger than in the last, somewhat crenately lobed, the margins often warty and gray-sorediate, the marginal lobes more expanded and elongated and more deeply lobed, those near the center closely imbricated and ascendant and often compacted into a granular and often gray-powdery crust, usually dark below where not obscured by the thin, black hypothallus; lower cortex very thin and sometimes scarcely developed; apothecia adnate, the disk commonly depressed, reddish brown or finally blackening, the margin not containing algal cells (in material seen), finally disappearing, rather small, 1 to 2 mm. in diameter; hypothecium pale to brownish; hymenium pale or pale brownish below and darker above; asci clavate; paraphyses commonly simple, the apices enlarged and usually brownish; spores simple, hyaline, ellipsoid-pointed, 20 to 28 μ long and 9 to 13 μ wide.

The fibrillose ring below the apothecia mentioned for Lake Superior specimens by Tuckerman has not been noticed in the material at hand.

Confined to the northeastern portion of the State. On rocks and wood.

Widely distributed in the northern United States and British America, but scarcely known to the South. Known also in Europe.



PANNARIA LEUCOSTICTA TUCK.

5. *Pannaria petersii* Tuck. Gen. Lich. 54. 1872.

Thallus squamulose-foliose, stellate, the lobes flat, clustered or scattered, radiately branched and many-cleft toward the circumference, frequently falling away at the center, olivaceous or black or rarely sea-green, the hypothallus absent, parenchymatous throughout, the lobes scarcely more than 0.5 mm. wide and reaching 1.5 to 3 mm. in length; plant when of definite form about 15 to 40 mm. in diameter; apothecia sessile, without thalloid exciple (biatoroid), the disk black and flat with a thin, raised margin, minute, 0.2 to 0.5 mm. in diameter; hypothecium light brown; hymenium pale below and slightly purplish above; paraphyses simple or branched, commonly thickened and purplish toward the apex; asci clavate; spores simple and 2-celled, oblong and ellipsoid, hyaline or pale, 12 to 24 μ long and 4 to 6 μ wide.

Collected on calcareous pebbles in the Leaf Hills in Ottertail County. The thallus was nearly obsolete, but the plant seems clearly to belong here.

A strictly North American lichen, hitherto reported from New York, Alabama, Tennessee, and Iowa.

6. *Pannaria nigra* (Huds.) Nyl. Not. Sällsk. Faun. Flor. Fenn. 5: 126. 1861.

Lichen niger Huds. Fl. Angl. ed. 2: 524. 1778.

Thallus composed of minute squamules, which are sometimes scattered but usually closely united into a more or less continuous granulose or coralloid crust, the slender lobes usually rounded, not exceeding 0.5 mm. in diameter, but sometimes branched and reaching 1 to 2 mm. in length in scattered conditions, lead-ashy in color, parenchymatous throughout; plants irregular in form and covering patches 15 to 50 mm. or more in diameter, resting upon and bordered by a prominent blue black hypothallus; apothecia sessile, without thalloid margin, the disk commonly black or more rarely reddish brown, flat or convex with a thin, elevated margin, which frequently disappears, minute, 0.3 to 0.8 mm. in diameter; hypothecium light brown or darker; hymenium pale below, and brownish or purplish above; asci clavate; paraphyses simple or rarely branched, commonly enlarged and colored toward the apex; spores oblong, 2 to 4-celled, 12 to 16 μ long and 4.5 to 7 μ wide.

Generally distributed in the State, but by no means common. On various rocks.

The plant from Grand Portage referred to *Pannaria flabellosa* belongs here.

Widely distributed in the United States and northward into British America and Alaska. Known in all the grand divisions.

Family STICTACEAE.

The family is represented in Minnesota by the genus *Sticta*, in which the algal symbiont is *Dactylococcus* or *Polycoccus*, both blue-green algæ, or the green *Cystococcus*. The thallus is large, plainly foliose, prostrate upon the substratum and well lobed. The cellular cortex is well developed above and below. Cyphellæ are usually present and constitute the most marked characteristic of the family. The apothecia are borne upon the upper surface of the thallus, scattered promiscuously, or marginal or submarginal. They vary from adnate to sessile. The spores are 2 to 4-celled and hyaline or brown.

The relationship of the Stictaceae and the Pannariaceae was discussed under the latter family. As reasons for separating the Stictaceae from the Peltigeraceae following may be noted the general presence in the former of cyphellæ and the different disposition of its apothecia. The presence may also be mentioned of upper and lower cortices in all the members of the former family and the absence of the lower cortex in most of the genera of the latter.

STICTA Ach. Lich. Suec. 3, 156, 257. 1798.

PLATE 26.

The thallus is foliose, commonly lobed and prostrate on the substratum, to which it is attached by rhizoids. The color is usually sea-green, yellowish, or brown. The cortex is developed both above and below, and the upper cortex is usually thicker than the lower. Underneath the lower cortex extend the rhizoids, and there are cyphellæ or naked spots on the lower side in most of the species. The medullary and algal layers occupy the usual positions. The algal symbiont is the common *Cystococcus* or probably *Dactylococcus* in the larger number of species. The genus has been variously divided, but there is scarcely any basis for such division at present and can not be until the plants included have been more thoroughly studied. The thallus is frequently pustulate, but the pustules are not conspicuous and they extend downward instead of upward as in *Umbilicaria pustulata*, thus forming a series of depressions which give the upper surface a reticulate appearance.

The apothecia are rather rare and are sessile on the upper surface, or are marginal or submarginal. The algæ of the thalloid margin sometimes die, in which case the margin appears externally to be lecideoid, or the margin may be overgrown by the apothecium and thus disappear. The hypothecium sometimes shows two distinct layers, the upper a network of mostly vertical hyphæ and the lower a pseudocellular layer, formed of gelatinized hyphæ extending for the most part horizontally. The cellular nature of the lower layer is by no means constant. The color is usually pale brownish. The paraphyses are usually simple and the apices thickened and brownish. The spores are 2 to 4-celled and hyaline or brown, or only very slightly colored. Their form is spindle-shaped or acicular.

The genus is somewhat closely related to members of the next family.

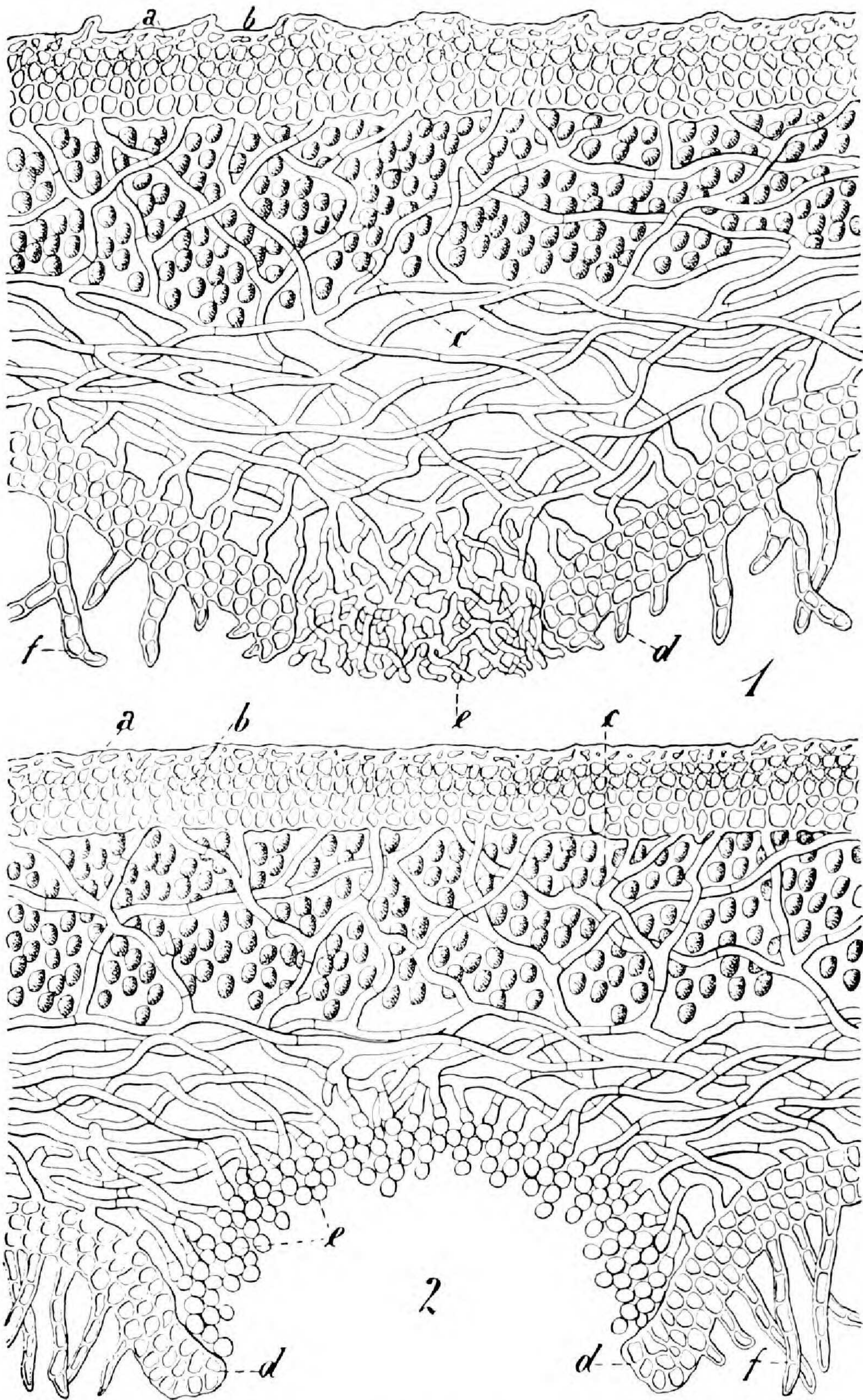
Seven species are found in the State.

Type species *Sticta sylvatica* Ach. loc. cit.

EXPLANATION OF PLATE 26.—Fig. 1, a section of the thallus of a *Sticta*; *e*, a cyphella composed of a network of hyphæ and protruding from an opening in the lower cortex of the thallus. Fig. 2, the form of cyphella found in *Sticta damacornis*, consisting of a depression in the lower side of the thallus and surrounded by hyphæ composed of almost spherical cells. In figs. 1 and 2 the usual layers of the thallus are also shown; *a*, the dermis; *b*, the upper cortex; *c*, the algal layer; *d*, the lower cortex; between *c* and *d*, the medullary layer; *f*, the rhizoids. Figs. 1 and 2 enlarged 400 diameters. From Schneider.

KEY TO THE SPECIES.

- Thallus without either cyphellæ or white spots below..... 1. *S. amplissima*.
 Thallus having either cyphellæ or white spots below.
 Thallus having white spots below.
 Thallus lobes long and frequently truncate..... 2. *S. pulmonaria*.
 Thallus lobes short and rounded..... 7. *S. scrobiculata*.
 Thallus having cyphellæ below.
 Cyphellæ sorediiform; thallus sea-green to brownish,
 often having yellowish green soredia above..... 3. *S. crocata*.
 Cyphellæ not sorediiform.
 Cyphellæ concave.
 Thallus brown or lead-colored, clothed above
 with blackish granules..... 5. *S. fuliginosa*.
 Thallus as above, only not clothed with
 granules..... 4. *S. limbata*.
 Cyphellæ urceolate; thallus brown, varying toward
 sea-green, more or less isidioid-granulose, espe-
 cially toward the margin..... 6. *S. quercizans*.



CYPHELLÆ.



SPECIES OF STICTA, PARMELIA, PYXINE, ETC., IN A CEDAR SWAMP.

1. **Sticta amplissima** (Scop.) Mass. Mem. Lich. 28. 1853.

Lichen amplissimus Scop. Fl. Carn. ed. 2. 2: 386. 1772.

Thallus rather closely adnate, more or less orbicular in outline, middle-sized or large, 6.5 to 20 cm. in diameter, smooth above or becoming more or less rugose, the lobes somewhat elongated and narrow or occasionally wider, sometimes more or less imbricated, with sinuate, subentire, or obscurely crenate margins; sea-green varying toward ash-color or brownish, below commonly lighter-colored and clothed usually with a spongy nap of small rhizoids with much larger rhizoids interspersed here and there, or the small rhizoids few or rarely wanting; devoid of cyphellæ or white spots and the rhizoids frequently becoming dark; apothecia sessile, scattered, the disk concave, chestnut-colored, the margin entire or crenulate, middle-sized, 1 to 3 mm. in diameter; hypothecium pale or brownish; hymenium pale below and pale or brownish above; paraphyses simple, the apex usually thickened and brownish; asci clavate or ovate-clavate; spores hyaline to light brown, 2 to 4 celled, 30 to 65 μ long and 4.5 to 7 μ wide.

Distributed throughout the northern portion of the State. On trees and rocks, especially on cedars in swamps.

Distributed throughout the eastern half of North America, but toward the south for the most part confined to mountains. Known in all of the grand divisions except South America.

2. **Sticta pulmonaria** (L.) Schaer. Enum. Lich. Eur. 30. 1850.

PLATE 27.

Lichen pulmonarius L. Sp. Pl. 1145. 1753.

Thallus middle-sized or large, 6.5 to 21 cm. in diameter, rather loosely attached to the substratum, prominently pustulate-reticulate, tawny-olivaceous varying toward sea-green, frequently soresiate or isidioid above, laciniately lobed, the lobes elongated and frequently deeply and narrowly sinuate, with retuse-truncate ends; beneath clothed with small brownish rhizoids which give a villous surface, with naked, raised, and whitish spots interspersed; apothecia adnate, usually submarginal, the disk chestnut, convex, the thalloid margin thin, entire or wrinkled and finally disappearing, middle-sized, 1.5 to 4 mm. in diameter; hypothecium not distinctly 2-layered, pale brownish; hymenium pale below and pale or pale brownish above; paraphyses simple or branched, the apex somewhat thickened and brownish; asci clavate; spores cymbiform, hyaline or pale, 2 to 4 celled, 18 to 33 μ long and 5.5 to 9 μ wide.

Confined to the northern portion of the State. On trees and rocks.

Distributed throughout the eastern half of North America, but confined to the mountains toward the south. Also extending to the Pacific coast in British America and Alaska. Known also in all of the grand divisions.

EXPLANATION OF PLATE 27.—View in a cedar swamp showing Stictas, Parmelias, and *Pyxine soresiate* on the prostrate tree at the front. About one-fortieth natural size.

3. **Sticta crocata** (L.) Ach. Lich. Suec. 158, 257. 1798.

Lichen crocatus L. Mant. Pl. 2: 310. 1771.

Thallus of medium size or larger, 5.5 to 14 cm. in diameter, rather loosely attached to the substratum, irregularly laciniate, more or less pitted or reticulately ribbed, commonly bordered and frequently more or less sprinkled above with yellowish green soresia, varying in color from sea-green to some shade of brown, the lobes wide and rounded with crenate or laciniate margins, more or less imbricated, below of the same color as above or darker, the rather small rhizoids forming a soft nap in which are scattered the more or less soresiiform cyphels; apothecia scattered or marginal, medium-sized with usually black disk, the thalloid margin crenate and more or less evanescent; spores 2-celled, brown, oblong-fusiform, 20 to 32 μ long and 9 to 10 μ wide.

Ours sterile, the spore and apothecial characters taken from Nylander.

Distributed throughout the northeastern portion of the State, as far west as Rainy Lake City and as far south as Duluth. On trees and also on shaded rocks.

Found in the mountains of the United States and descending to lower altitudes in the extreme northern portion and in British America and Alaska. Known in all of the grand divisions except Asia.

4. *Sticta limbata* (Turn.) Ach. Meth. Lich. 280. 1803.

Lichen limbatus Turn. in Sowerby, Engl. Bot. **16**: pl. 1104. 1802.

Thallus rather loosely attached to the substratum, usually orbicular in outline with short rounded lobes, rather small, ours being only 2.5 to 4 cm. in diameter, smooth above or sometimes slightly scrobiculate, usually monophyllous, sometimes more or less sorediate toward or along the margins (not in ours); usually brown but varying toward lead-color, below paler and clothed with rhizoids forming a soft nap, in which are to be found the whitish depressed cyphellæ; apothecia scattered over the upper surface, adnate, convex, the thalloid margin disappearing early, the disk a dull black; small, 0.5 to 1 mm. in diameter; hypothecium brownish; hymenium brownish toward the base and darker brown above; paraphyses simple or branched, the apex thickened and brownish; asci clavate or ovate-clavate; spores brown, 2-celled, oblong-ovate, constricted, 15 to 20 μ long and 5 to 7 μ wide.

Once collected in the State. On trees at Tofte.

Previously reported in North America from Oregon, Alaska, and Labrador. Also known in Europe and a subspecies in Africa.

5. *Sticta fuliginosa* (Dicks.) Ach. Lich. Suec. 158, 257. 1798.

FIGURE 12.

Lichen fuliginosus Dicks. Pl. Crypt. Brit. **1**: 13. 1785.

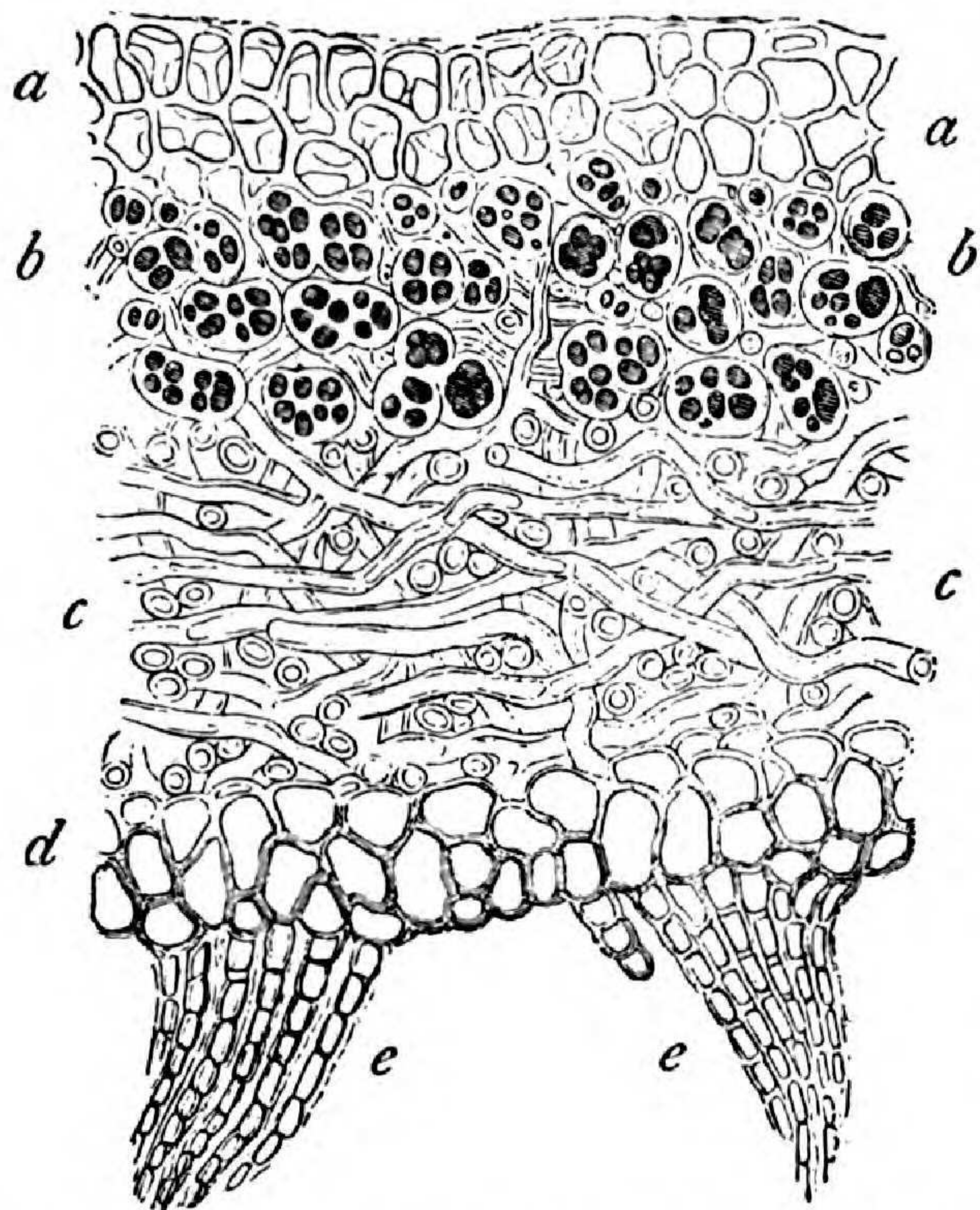


FIG. 12.—*Sticta fuliginosa*, showing a section of the thallus. *a*, The upper cortex; *b*, the algal layer; *c*, the medullary layer; *d*, the lower cortex; *e*, the rhizoids. Enlarged 500 diameters. From Sachs.

Thallus rather loosely attached to the substratum, more or less orbicular in outline, middle-sized, 2.5 to 12 cm. in diameter; more deeply lobed than the last, but the lobes still rounded, smooth above or slightly scrobiculate or more or less clothed with blackish granules, usually brownish above but frequently varying toward gray or lead-color, below paler and clothed with rhizoids, these forming a soft nap, in which are embedded the concave whitish cyphellæ; apothecia usually marginal, smallish, about 1 mm. in diameter, the thalloid exciple evanescent, the disk convex and reddish brown; spores pale or hyaline, 2 to 4-celled, 25 to 43 μ long and 7 to 9 μ wide. Ours sterile, the spore and apothecial characters from Nylander.

Confined to the northwestern portion of the State, occurring as far east and south as Tower. Usually on cedars in swamps. The species is so near to the last that the two are very difficult of separation.

A widely distributed species in North America. Known in all the grand divisions except possibly Asia.

6. *Sticta quercizans* (Michx.) Ach. Syn. Lich. 234. 1814.

Lobaria quercizans Michx. Fl. Bor. Amer. **2**: 324. 1803.

Thallus more closely attached to the substratum, more or less orbicular in outline, middle-sized or large, 5 to 17.5 cm. in diameter, the lobes somewhat longer and



STICTA SCROBICULATA (SCOP.) ACH.

narrower and laciniate, with usually more or less raised entire or crenate margins, frequently somewhat imbricate, smooth above or more or less isidioid-granulate, especially along the margins; upper surface brown, varying toward sea-green but seldom showing the reddish tendency of more southern specimens; lower surface paler and clothed with light brown or darker rhizoids, these forming a spongy nap in which are embedded the urceolate whitish cyphellæ; apothecia usually submarginal, the disk reddish brown, the exciple thin, usually entire and finally losing its algal cells, middle-sized, 2 to 3 mm. in diameter; spores hyaline or pale, fusiform, 4-celled, 30 to 32 μ long and 8 to 9 μ wide.

Ours are uniformly sterile, and the above spore and apothecial characters are taken from Nylander.

Confined to the northern portion of the State. Commonly on cedars in swamps, but sometimes on rocks or other trees.

The plant is widely distributed in North America. Also known in all the grand divisions except Europe.

7. *Sticta scrobiculata* (Scop.) Ach. Lich. Univ. 453. 1810.

PLATE 28.

Lichen scrobiculatus Scop. Fl. Carn. ed. 2. 384. 1772.

Thallus somewhat loosely attached to the substratum, more or less orbicular in outline, middle-sized or larger, 4.5 to 15 cm. in diameter, smooth and scrobiculately pitted and clothed more or less with grayish soredia, sea-green, varying toward yellow, the lobes short and rounded with undulate or crenate margins, below clothed with usually dark rhizoids, giving a villous surface interspersed here and there with light naked spots, these resembling somewhat in appearance the cyphellæ of our other *Stictas*; apothecia scattered, small to middle-sized, sessile, the disk reddish brown, the margin entire; hypothecium rather indistinctly 2-layered, the upper layer thinner and brownish, the lower wider and pale; hymenium pale or brownish; paraphyses frequently branched, the apex often enlarged and brownish; asci ovate-clavate; spores long-fusiform, 4 to 8-celled, hyaline or pale, 50 to 75 μ long and 5 to 7 μ wide.

Ours are always sterile, and the spore and apothecial characters were taken from European specimens.

Found only along the north shore of Lake Superior. On mossy rocks or on trees.

Frequent in New England and northward throughout the eastern half of British America and found also in Alaska. Known also in Europe, Asia, and Africa.

EXPLANATION OF PLATE 28.—Plant on a mossy trunk, showing the characteristic lobed and pitted thallus. Natural size.

Family PELTIGERACEAE.

The family as represented in our flora includes three genera, of which *Peltigera* may be regarded as the most typical. In this there is a total absence of lower cortex, though the species are usually large and have foliose thalli not more closely attached to the substratum than are members of the *Stictaceae*. However, in the genus named above, the lower cortex is more or less replaced by a layer of hyphæ running horizontally below the medullary layer. The trichomatic hyphæ are also usually present in the species. In one of the other two genera, *Solorina*, the lower cortex is scarcely developed, but in the other, *Nephroma*, it is well developed. *Solorina* is thus more nearly typical as regards the cortex, but the genus is somewhat aberrant in that the apothecia are scattered over the upper surface of the thallus and not confined to the lobes as in the other two genera. In *Nephroma* there is a well developed cortex below, and in this respect the genus is the highest member of the family. The apothecia of *Nephroma* are typical of the family in that they are immersed in the lobes, but their location is peculiar in being removed to the lower side of the lobes.

The relationship of the present family with the last was stated under that family. The spore characters and the algal symbionts are indicated in the Outline of Classification and under the several genera.

With the Peltigeraceae we reach the climax in a line of development in lichens, conducted hither through several closely related families. Accordingly the present family does not show close relationship with any of the families to follow.

SOLORINA Ach. Lich. Univ. 27, 149. *pl. 1. f. 5, 6.* 1810.

The thallus is foliose, rather indistinctly lobed, prostrate but rather loosely attached to the substratum. Its structure resembles that of *Peltigera* in the absence or very rudimentary development of the lower cortex. The upper cortex is present, and is frequently thick in some areas and thin in others. Two kinds of algæ occur in the same plant, supposed to be a *Dactylococcus* and a *Polycoccus*. The former predominates and commonly lies for most part above the other, extending nearly to the upper surface below the thin places in the upper cortex. The medullary layer is well developed and extends below into a thicker layer of hyphæ, lying for the most part in a horizontal position. Bundles of hyphæ form ridges or veins on the lower surface similar to the veins of *Peltigera*. Rhizoids are more or less common, extending downward from the lower surface.

The apothecia as a whole resemble those of *Peltigera*, though they are scattered over the upper surface and are even more common near the center instead of being marginal. They are commonly impressed, though they may be more or less raised. The thalloid margin is usually wanting, but may be made out occasionally, especially when the apothecia are somewhat raised. The hypothecium and the hymenium are pale or else light or darker brownish. The paraphyses are commonly simple and the spores are 2-celled and brown.

The close relationship of the genus to *Peltigera* as regards structure of thallus and apothecia has already been noted. The spore characters of the two genera, however, are so different that the relationship can not be as close as would be supposed from a consideration of the thallus and apothecia alone.

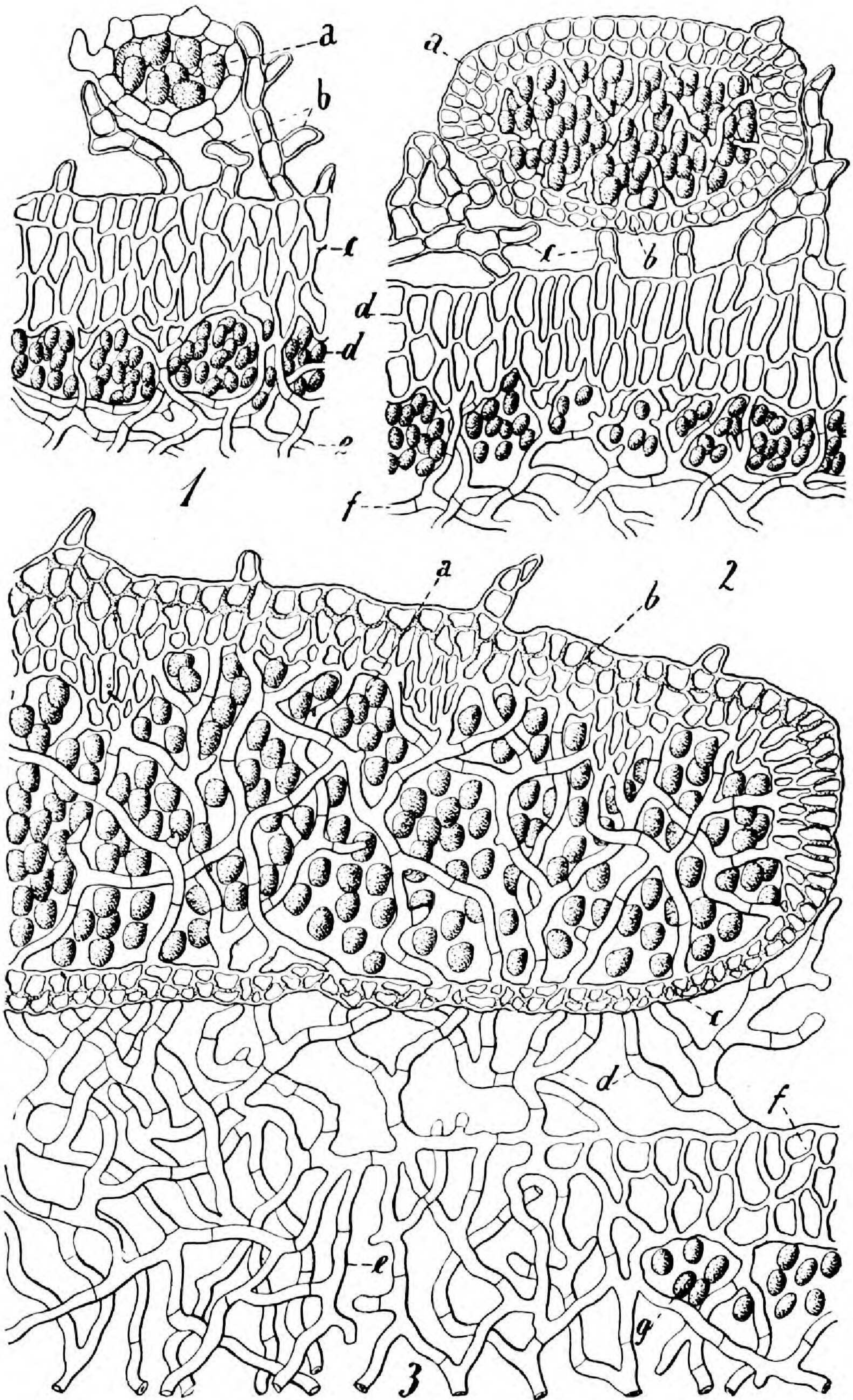
A single species occurs along the shores of Lake Superior. On earth or mossy rocks. Type species *Solorina crocea* (L.) Ach. loc. cit.

Solorina saccata (L.) Ach. Lich. Univ. 149. *pl. 1. f. 6.* 1810. PLATE 23, B.
Lichen saccatus L. Sp. Pl. ed. 3. 1616. 1764.

Thallus foliose, rather loosely attached to the substratum, smoothish above, more or less orbicular, small or middle-sized, 20 to 75 mm. in diameter, the lobes rather short, wide and rounded, the ends subentire or more or less irregularly incised, sea-green varying toward ashy or brownish, below lighter in color, but sometimes darkening, cottony and obscurely veined and rhizoid-bearing, the upper cortex quite uniform in thickness; apothecia commonly sunken into the thallus, the disk more or less concave, dark brown, the thalloid margin seldom distinguishable, middle-sized, 2 to 6 mm. in diameter; hypothecium light brown; hymenium pale below and pale brownish above; paraphyses commonly simple, frequently enlarged and brownish toward the apex; asci cylindrical; spores ellipsoid, 40 to 60 μ long and 16 to 22 μ wide.

The plant is rare in Minnesota. It has been collected on mossy rocks at Grand Portage and near Pork Bay, thus apparently confined to the shore of Lake Superior.

Scattered across the northern United States from the Rocky Mountains to the Atlantic Ocean, but confined for the most part to mountains or cold shores. More generally distributed throughout British America. Also known in Europe and Asia.



CEPHALODIA OF PELTIGERA APHTHOSA (L.) WILLD.

PELTIGERA Willd. Fl. Berol. Prodr. 347. 1787.

PLATE 29.

The thallus is foliose, more or less lobed and rather loosely attached to the substratum. The common color is sea-green varying toward brown. The structure is peculiar in the total absence of a lower cortex, while there is a well developed upper one. The algal layer is in the usual position just below the cortex, and the portion of the thallus below the algal layer is somewhat differentiated, in that the hyphæ of the lower portion run in a somewhat horizontal direction and together with the usually numerous rhizoids serve for support and also for protection against too rapid evaporation of moisture, thus functioning somewhat like a true cortex. The plants are usually more or less veined below. In some of the species the upper surface is more or less clothed with hyphæ, which give a downy appearance and which are structurally and functionally comparable to the trichomes of higher plants. These hyphæ have thick walls, and the cells are short. The algal symbiont is doubtless nearly always *Polycoccus* or *Dactylococcus*, though the chains of cells can hardly be discerned. In one of our species cephalodia occur on the upper surface of the thallus.

The apothecia are usually orbicular, and are found on the margins of the lobes of the thallus. They are usually immersed in the lobes and present somewhat the appearance of those of *Heppia* and *Solorina*. The hypothecium is pale or slightly colored. The hymenium is commonly brownish above. The paraphyses are commonly simple, though branched forms may be found in all of the species. The spores are fusiform or acicular, 4 to 8-celled, hyaline, or brownish, and frequently more or less curved.

Notwithstanding the absence of a lower cortex, there is a somewhat close relationship between the present genus and *Nephroma* and *Sticta*.

Eight species occur in the State, and one of them is represented by five distinct forms. On earth or more rarely on old wood or rocks.

Type species *Peltigera aphthosa* (L.) Willd. loc. cit.

EXPLANATION OF PLATE 29.—Cephalodia of *Peltigera aphthosa*. Fig. 1, *a*, a young cephalodium; *b*, the trichomatic hyphæ holding the cephalodium. Fig. 2, an older cephalodium; *a*, the internal hyphæ and algal cells; *b*, the well-developed cortex; *c*, the supporting trichomatic hyphæ. Fig. 3, a mature cephalodium; *a*, the internal hyphæ and algal cells; *b*, the upper cortex; *c*, the lower cortex; *d*, the supporting hyphæ; *e*, the thallus below the cephalodium, where the algal cells have disappeared and the cortex is transformed into hyphal tissue; *f*, the cortex; *g*, the algal layer of the supporting thallus. Fig. 1, enlarged about 100 diameters; fig. 2, enlarged 400 diameters; fig. 3, enlarged 200 diameters. From Schneider.

KEY TO THE SPECIES.

- Thallus cephalodia-bearing above..... 1. *P. aphthosa*.
 Thallus not cephalodia-bearing above.
 Thallus devoid of trichomatic hyphæ above.
 Thallus lobes small and roughly fan-shaped..... 2. *P. venosa*.
 Thallus lobes larger, not fan-shaped.
 Apothecia-bearing lobes more or less digitately clustered; spores 4 to 8-celled, elongated..... 4. *P. polydactyla*.
 Apothecia-bearing lobes not digitately clustered; spores 4-celled, much shorter..... 3. *P. horizontalis*.
 Thallus having trichomatic hyphæ above.
 Margins of the lobes frequently isidioid-granulate, lobulate or sorediate..... 5. *P. scutaia*.
 Margins not isidioid and not lobulate or sorediate.
 Lower surface of the thallus partly or wholly brownish or blackish.
 Apothecia orbicular..... 6. *P. malacea*.
 Apothecia oblong or revolute..... 7. *P. rufescens*.

Lower surface of the thallus whitish.

Thallus middle-sized.

Rhizoids moderately developed 8. *P. canina*.

Rhizoids numerous and forming a spongy
nap 8a. *P. canina spongiosa*.

Thallus smaller or thinner.

Thallus thinner but expanded 8d. *P. canina leucorhiza*.

Thallus smaller.

Thallus scarcely rhizoid-bearing, but
sorediate 8c. *P. canina sorediata*.

Thallus scarcely rhizoid-bearing, not
sorediate 8b. *P. canina spuria*.

1. *Peltigera apthosa* (L.) Willd. Fl. Berol. Prodr. 347. 1787. PLATES 29, 30.
Lichen apthosus L. Sp. Pl. 1148. 1753. ^a

Thallus somewhat closely attached to the substratum, with the margins or the entire lobes more or less ascending, middle-sized to large, 6 to 20 cm. in diameter, sprinkled more or less with the small and irregular cephalodia, smooth above and devoid of trichomatic hyphæ, except those lying below and closely adhering to the cephalodia to hold them in place, the lobes broad and rounded and sometimes more or less imbricated, the margins subentire or more commonly somewhat crisped and variously irregular; from apple-green to sea-green or rarely even brownish, below white and rarely white-veined, but the veins more commonly dark and even the whole surface becoming so, the veins clothed with delicate rhizoids, these composing a close nap, the surface also bearing scattered larger rhizoids; apothecia on somewhat extended lobules, middle-sized or larger, 4 to 8.5 mm. in diameter, ascendant, frequently becoming revolute or convolute, often superficial, the margin entire or crenulate, the disk reddish brown; hypothecium brownish; hymenium pale or brownish below and darker above; paraphyses simple or rarely branched, commonly thickened and brownish toward the apex; asci cylindrico-clavate; spores acicular, colorless or showing pale brownish in the asci, 4 to 8-celled, 45 to 75 μ long and 4 to 7 μ wide.

Generally distributed over the northern portion of the State. On earth and frequently on humus-covered rocks.

Distributed much as the next in North America, but extending southward, at least in the mountains. Also known in Europe and Asia.

EXPLANATION OF PLATE 30.—Plant on earth, showing the ascending thallus lobes dotted over with cephalodia. Natural size.

2. *Peltigera venosa* (L.) Hoffm. Deutsch. Fl. 2: 107. 1795.
Lichen venosus L. Sp. Pl. 1148. 1753.

Thallus usually composed of scattered lobes, each of which may be regarded as a plant, or rarely more or less connected into a larger thallus, the single or more rarely united lobes somewhat ascending, commonly more or less fan-shaped or in the form of an isosceles triangle, smooth and devoid of trichomatic hyphæ above, sea-green varying toward ashy or brownish, the margins of the nonfertile lobes entire or somewhat wavy, below white between brown veins, the latter bearing small rhizoids and sometimes spreading until they cover nearly all of the lower surface, the lobes 8 to 20

^aThe original spelling was by error *apthosus*.



PELTIGERA APHTHOSA (L.) WILLD.

mm. long and frequently as wide at the anterior end so that they become roughly equilateral; apothecia along the margins, usually the anterior margin, superficial and rounded, with entire or crenulate, thalloid, but commonly brown and apparently biatoroid exciple, horizontal with flat brown to blackish disk, middle-sized, 2 to 5 mm. in diameter; hypothecium brown or brownish; hymenium pale or brownish below and darker above; paraphyses simple or rarely branched, enlarged and brownish toward the apex; asci cylindrico-clavate; spores fusiform, frequently pale brown, 28 to 45 μ long and 6 to 9 μ wide, but rarely longer, and 5-celled instead of 4-celled in ours.

Collected at Grand Portage and at South Fowl Lake. On earth and mossy rock; a rare plant in Minnesota.

Widely distributed in the northern portion of the United States, especially in mountainous country, and common northward to arctic America. Known also in Europe and Asia.

3. *Peltigera horizontalis* (L.) Hoffm. Deutsch. Fl. 2: 107. 1795.

Lichen horizontalis L. Mant. Pl. 2: 132. 1771.

Thallus somewhat closely attached to the substratum, but the margins of the lobes more or less ascending, middle-sized or larger, 6 to 19.5 cm. in diameter, the upper surface usually smooth and shining and devoid of trichomatic hyphæ, the margins of the wide lobes rounded and entire, undulate, or variously irregular, sea-green varying toward ashy brown, or reddish brown, below bearing large rhizoids commonly dark in color and smaller ones of the same colors, the latter forming a close nap, the nap and larger rhizoids usually lighter-colored toward the margin; veins not conspicuous in ours; apothecia on somewhat narrowed lobes, submarginal and frequently superficial, middle-sized, 3 to 5 mm. in diameter, transversely oblong, commonly flat, the disk reddish brown; hypothecium commonly brownish; hymenium pale, or brownish above; paraphyses simple or rather rarely branched, usually enlarged and brownish toward the apex; asci cylindrico-clavate; spores 4-celled, 30 to 48 μ long and 5.5 to 8 μ wide.

Distributed throughout the northern portion of the State. On earth in swamps and rarely over mossy rocks.

The plant is widely distributed in North America. Known also in Europe and Africa.

4. *Peltigera polydactyla* (Neck.) Hoffm. Deutsch. Fl. 2: 106. 1795.

Lichen polydactylon Neck. Meth. Musc. 85. 1771.

Thallus attached much as in the last and of about the same size, likewise having ascending lobes and smooth, shining upper surface devoid of trichomatic hyphæ, the margins of the lobes much as in the last, except those bearing apothecia, these usually digitately clustered and more elongated, sea-green, lead-colored, or rarely becoming brownish, below bearing rhizoids as in the last, but on the whole lighter-colored, reticulated with commonly brown or darker veins and not conspicuously covered with nap, lighter toward the margin; apothecia middle-sized, 3 to 5 mm. in diameter, rounded or more commonly revolute, the disk reddish brown; hypothecium commonly brownish; hymenium pale, or brownish above; paraphyses simple or rarely branched, commonly thickened and brownish toward the apex; asci clavate or cylindrico-clavate; spores 4 to 8-celled, 60 to 100 μ long and 3 to 4 μ wide.

This species and the last are very difficult to distinguish macroscopically, but the spore characters are perfectly distinct.

Confined to the northern portion of the State, a single specimen recorded from Minneapolis being doubtful. On earth, especially in swamps.

Generally distributed throughout North America. Known in all of the grand divisions.

5. *Peltigera scutata* (Dicks.) Leight. Lich. Fl. Great Brit. 110. 1871.

Lichen scutatus Dicks. Pl. Crypt. Brit. 3: 18. 1793.

Thallus much as in the last, but not so uniformly smooth and sometimes having trichomatic hyphæ over at least portions of the upper surface, rather small to middle-sized, 6 to 14.5 cm. in diameter, the margins of the lobes usually rounded, crisped and frequently isidioid-granulate or isidioid-lobulate (not sorediate in ours), the fertile ones short and scattered, sea-green varying toward ashy or brownish, beneath light with brown veins, or in ours the whole lower surface, except the margins, becoming dark brown; apothecia rather smaller than in the last, orbicular or transversely oblong, the disk reddish brown; spores 4 to 8-celled, 50 to 70 μ long and 3 to 4 μ wide.

Typical forms not fruited in ours, and spore and apothecial characters taken from Tuckerman.

Recorded from Minneapolis and Taylors Falls as *Peltigera pulverulenta* (Tayl.) Nyl.^a The best forms seem to differ sufficiently from either of the last two, but in the absence of fruit, the plants here recorded must be regarded as uncertain. A peculiar feature both in Iowa and Minnesota plants is the fact that the thallus is quite commonly found growing over blackened, dead thalli of the same kind, sometimes three or more layers thus appearing one above another. On earth, usually under trees.

Seems to be widely distributed in North America, though not often collected. Known also in Europe.

6. *Peltigera malacea* Ach. Syn. Lich. 240. 1814.

Thallus rather more loosely attached to the substratum and the lobes perhaps more ascending than in most of the species, middle-sized, 6.5 to 15 cm. in diameter, the upper surface commonly not so smooth and shining, but finely granular or even minutely downy, owing to the presence of scattered or more numerous trichomatic hyphæ, sea-green, varying toward ashy or more commonly toward brownish, the lobes somewhat narrower, rounded with entire or undulate margins, beneath light-brown to blackish, but paler and sometimes white-foveolate toward the margin, larger rhizoids few or absent, and the surface scarcely veined but uniformly clothed with a dense nap; apothecia on extended lobes, middle-sized or larger, 3 to 7.5 mm. in diameter, orbicular, the disk brownish-black; hypothecium dark brown; hymenium pale brown below and darker above; paraphyses simple or rarely branched, commonly enlarged and brown toward the apex; asci cylindrico-clavate; spores 4 to 6-celled, 50 to 75 μ long and 4 to 6 μ wide.

The plant has been found at Grand Marais, at Tower, and westward from Kettle Falls along the international boundary. On thin earth over rocks.

Known in the White Mountains, the Rocky Mountains, and northward to Newfoundland and Greenland. Found in all of the grand divisions except Australia.

7. *Peltigera rufescens* (Neck.) Hoffm. Deutsch. Fl. 2: 107. 1795.

Lichen rufescens Neck. Meth. Musc. 79. 1771.

Thallus closely adnate with ascending margins, scarcely middle-sized, 6 to 12.5 cm. in diameter, the upper surface rather sparingly covered with trichomatic hyphæ and downy or entirely devoid of them and smoother, the lobes more crowded and narrower than in the next with elevated and crisped margins, sea-green or more commonly becoming brown or reddish brown, beneath reticulated with brown veins, these more or less rhizoid-bearing, in ours the whole lower surface, except toward the margins, becoming dark brown; apothecia on extended lobes, middle-sized or larger, 3.5 to 7.5 mm. in diameter, becoming vertical, oblong or revolute, the disk reddish brown varying toward blackish; hypothecium brown or brownish; hymenium commonly pale brownish below and darker above; paraphyses simple or rarely branched,

^aNyl. Syn. Meth. Lich. 1: 325. 1858.

the tips usually enlarged and brownish; asci long-clavate; spores 4 to 8-celled, 40 to 65 μ long and 3 to 5 μ wide.

The plant has been noted in all parts of the State except the northeastern portion, but much of the material is uncertain and may belong in some instances to the next or more probably to *Peltigera scutata* (Dicks.) Leight. There is a form which seems to belong distinctly to the above description, but there is much confusion both in America and in Europe as to the relation of the present species and the next, a fact that is apparent enough in examining the exsiccati of the best lichenists.

On earth under trees, on rocks or on the bases of tree trunks.

The plant is widely distributed in North America. Known in all of the grand divisions.

8. *Peltigera canina* (L.) Hoffm. Deutsch. Fl. 2: 106. 1795.

FIGURE 13.

Lichen caninus L. Sp. Pl. 1149. 1753.

Thallus closely adnate toward the center, but more or less ascending toward the margins of the lobes, middle-sized to large, 7.5 to 25 cm. in diameter, the upper portion clothed for the most part with trichomatic hyphæ, giving a downy appearance

under the lens, the lobes wide with usually rounded but sometimes irregular or crenate margins or even much crisped, sea-green to brownish, below whitish or rarely brownish toward the center, with veins and rhizoids of the same color; apothecia middle-sized or larger, 4 to 8 mm. in diameter, on long and usually nearly erect lobes, rounded more commonly semirevo-

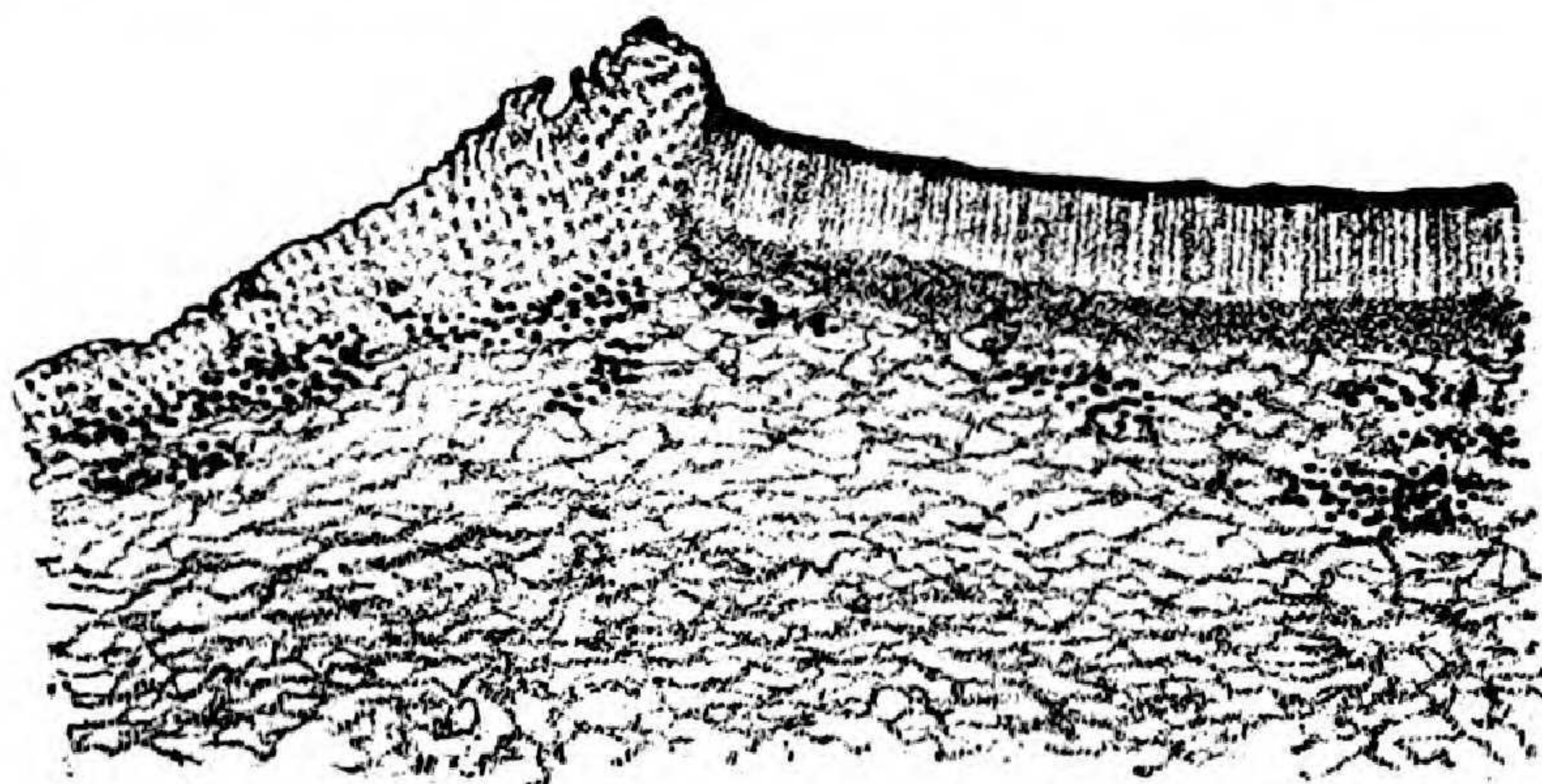


FIG. 13.—*Peltigera canina*. Section of a portion of an apothecium, showing immersion. Enlarged 45 diameters. From Reinke.

lute, the disk reddish brown, becoming vertical; hypothecium brownish; hymenium usually pale below and brownish above; paraphyses simple or rarely branched, frequently enlarged and brownish toward the apex; asci long-clavate; spores 4 to 8-celled, 38 to 72 μ long and 3 to 5 μ wide.

Generally distributed over the State. Habitats as in the last.

Found in all portions of North America, but preferring mountains to the south. Known in all of the grand divisions except Australia.

8a. *Peltigera canina spongiosa* Tuck. Gen. Lich. 38. 1872.

The pale veins of the lower side passing into tufted rhizoids, of the same color or darkening, these frequently running together into a conspicuous spongy nap.

Ours are large plants, and the trichomatic hyphæ are usually large and numerous. Commonly sterile.

Rare in the northern portion of the State, and a single doubtful specimen has been recorded from Redwood Falls. On earth or over mosses in swamps.

The subspecies is recorded from a few localities in the northern United States and is more common northward, extending into arctic regions. An American form, known only in North America.

8b. *Peltigera canina spuria* (Ach.) Tuck. Gen. Lich. 38. 1872.

Lichen spurius Ach. Lich. Suec. 159. 1798.

The cream-colored veins of the lower side scarcely rhizoid-bearing, the fertile lobules somewhat digitately clustered, the whole thallus including the apothecia reduced in size, lobes 15 to 45 mm. in length. Not differing microscopically.

Generally distributed over the State. On earth and old wood.

The North American distribution seems to be about the same as that of the species. Also known in Europe and Asia.

8c. *Peltigera canina sorediata* (Schaer.) Fink, Bull. Lab. Nat. Hist. Univ. Iowa **3**: 76. 1895.

Peltigera canina spuria sorediata Schaer. Enum. Lich. Eur. 21. 1850.

Thallus small, composed of usually scattered lobes, these soresidate and 10 to 45 mm. in length, the ends usually rounded and sterile; beneath either bearing rhizoids or not; apothecia rather smaller than in the species, not differing microscopically.

Found in all portions of the State. On earth or old logs in moist shaded places.

North American distribution the same as that of the last, into which it frequently passes. Known also in Europe.

8d. *Peltigera canina leucorrhiza* Floerke, Deutsch. Lich. no. 53. 1821.

Thallus rather expanded and thinner, the conspicuous veins and scattered rhizoids white. The largest form of the species, reaching 27.5 cm. in diameter, or the large rounded lobes scattered. Usually sterile; trichomatic hyphæ abundant and large; apothecia not seen.

Found in the northern portion of the State. On earth or over mosses in swamps.

Agrees with material determined from Newfoundland by Arnold. Nothing further known of its American distribution. Known in Europe.

NEPHROMA Ach. Lich. Univ. 101, 521. *pl. 11. f. 1.* 1810.

The thallus is foliose and bears a general external resemblance to that of *Peltigera*, though smaller, usually darker in color and devoid of trichomatic hyphæ. It lies horizontally on the substratum, to which it is usually more or less closely attached by rhizoids. The cortical layer is developed on both sides, the upper cortex being much thicker than the lower. The algal and medullary layers are well developed. There is some uncertainty regarding the algal symbiont, and Nylander has divided the genus, establishing the genus *Nephromium*, the distinction being based upon the difference in the algæ. All of our species would fall under his newer genus were we to follow his distinction. However, we have retained the older name, awaiting further studies. The algæ in ours are blue-green, and seem to be the same as in *Peltigera*, viz, *Polycoccus*.

The apothecia are confined to the lower side of the thallus, and this feature serves to distinguish the members of the genus from members of closely related genera as *Peltigera* and *Solorina*. However, the apothecia are marginal or submarginal, and the disk is more or less turned upward and may even stand erect. They are of good size, somewhat impressed in the more or less elongated lobes which bear them. The algal cells commonly disappear from the thalloid margin, which may itself be evanescent. The hypothecium is pale or brownish. The paraphyses are commonly simple with apices enlarged and brownish. The spores are brown or brownish, and commonly 4-celled in ours.

The genus is certainly closely related to *Peltigera* as to apothecial characters and also as regards general appearance of the thallus. As regards microscopic features of the thallus and the spores, it seems nearer to *Sticta*.

Four species and subspecies have been found in the northern portion of the State, a single species extending as far south as Taylors Falls.

The plants occur on trees, rocks, and occasionally on soil, and are quite commonly found on mosses overrunning these substrata.

Type species *Nephroma polaris* Ach. loc. cit. (*Nephroma arctica* (L.) Fr.)

Found only in the northern portion of the State. On rocks and trees.

North American distribution essentially the same as that of *Nephroma tomentosum*, though not thus far collected within the United States to the west. Occurs in all of the grand divisions except Asia.

3a. *Nephroma laevigata parilis* (Ach.) Tuck. Syn. N. A. Lich. 1: 104. 1882.

Lichen parilis Ach. Lich. Suec. 164. 1798.

Thallus lobes sprinkled, especially at the margins, with gray soredia and more frequently darker or even blackish below.

Said to be thinner and softer than the type. Ours always sterile.

Collected at Kettle Falls and at Grand Portage. On rocks.

In New England and widely distributed in British America. Also known in South America, Europe, and Asia.

Family **GYROPHORACEAE.**

The family has two genera, *Gyrophora* and *Umbilicaria*. If we take into account thallus structure and likewise the peculiar disposition of the apothecia, the family is sufficiently distinct. Tuckerman did not divide into two genera, but recognized the family as consisting of the single genus *Umbilicaria*. He regarded the family as related to the *Parmeliaceae* and the *Physciaceae* through the foreign *Omphalodium*. However, the relation is by no means close, as comparison of both vegetative and reproductive tracts will reveal. Schneider, on the other hand, sees in the two genera of the present family the highest expression of the *Lecideaceae* and places both genera in that family. Yet this position seems hardly tenable, and it does not appear that the present family is more closely related to the *Lecideaceae*, as limited in this volume, than to the *Parmeliaceae* or the *Physciaceae*.

In the development of a strong central attaching organ, the umbilicus, and in the external appearance and the anatomical structure of the thallus, there is a considerable resemblance to the better developed *Dermatocarpons*, but when we consider the difference in apothecial structure it appears that the relationship here is also rather remote. Thus it seems that the family is a very distinct one, whose relationships are difficult to trace. Perhaps it might have been better to follow Zahlbruckner in placing the present family next to the *Parmeliaceae*, but this disposition is again uncertain, and the *Lecanoraceae* certainly show stronger affinities with the *Parmeliaceae* than does the present family.

Members of the family can hardly be confused with any other lichens except certain *Dermatocarpons*, and careful study of the thallus structure, and more especially of the apothecial characters, will enable one to distinguish readily enough. The general character of the thallus structure and the peculiar disposition of the apothecia are stated in the descriptions of the two genera.

GYROPHORA Ach. Meth. Lich. xxxi, 100. *pl. 2. f. 6.* 1803.

The thallus is foliose and is attached to the substratum by an umbilicus. The margin of the thallus may be entire, but is more usually irregularly incised or torn. A cellular cortex is developed on all sides. The upper cortex is quite thin, and the walls are gelatinized and the cells small. The lower cortex is strongly developed and thickened in order to furnish support for the frequently large thalli supported only at one point. This last feature is unusual in foliose lichens. The lower cortex is, moreover, usually quite uneven in thickness. The medullary tissue is frequently rather thin for so large a thallus. The algal symbiont is *Cystococcus*. The umbilicus is a stem of cortical tissue, supporting the thallus. Or its lower portion is rather a dense bundle of hyphae constituting a large rhizoid. From its base long branching rhizoids extend into the substratum. The prevailing colors of the upper surface are brown,



GYROPHORA HYPERBOREA ACH.

black, and gray. The lower surface is commonly black and is usually roughened or ciliate. In some of the species longitudinal or vertical plates for support replace the rhizoid-like cilia of the lower side of the thallus.

What is commonly considered an apothecium seems rather to be a group of (usually elongated) apothecia closely clustered upon a very short dichotomously branching pedicel. This peculiar structure is very apparent as seen in sections, and even with a hand lens the individual apothecia may usually be plainly distinguished. The apothecia sometimes occur singly. There is a thalloid exciple, usually blackened and devoid of algal cells. The paraphyses are simple or branched. The spores are simple, ellipsoid in form, and pale or hyaline.

The genus is peculiar in many ways, as appears from a study of the above brief description, and is not very closely related to any other genus except *Umbilicaria*, which is commonly included with *Gyrophora*. The two genera show forms with thalli closely resembling *Endocarpon* externally.

Four species of the genus occur in Minnesota, all in the northern portion of the State. Ours are always found on the igneous or metamorphic rocks.

Type species *Gyrophora arctica* Ach. op. cit. 106.

KEY TO THE SPECIES.

- Thallus ash-colored above, rhizoid-bearing below..... 3. *G. vellea*.
 Thallus brownish, ashy brownish, or blackish above, with or without rhizoids.
 Thallus clothed below with long, dark rhizoids..... 4. *G. dillenii*.
 Thallus without rhizoids below.
 Thallus more or less pitted and lacunose below..... 1. *G. hyperborea*.
 Thallus reticulated with plates below..... 2. *G. muhlenbergii*.

1. *Gyrophora hyperborea* Ach. Meth. Lich. 104. 1803.

PLATE 31.

Lichen hyperboreus Ach. Vet. Akad. Handl. 15: 89. 1794.

Thallus rounded or irregular in form, the edges more or less jagged and irregular, and sometimes even irregularly lobed, small or middle-sized, 30 to 75 mm. in diameter, papulose-roughened, sometimes sparingly perforate, usually occurring singly but sometimes several thalli more or less imbricated in a cluster; olivaceous or blackish brown, beneath brown to blackish, smooth and more or less pitted and lacunose; apothecia sometimes single but usually in groups, the groups considerably raised and black, more or less rounded and convex, 0.5 to 2.5 mm. in diameter and sometimes containing 100 or over more or less elongated and variously curved apothecia, each apothecium having a black thalloid exciple; hypothecium dark brown; hymenium pale to light brown; paraphyses simple or branched, commonly thickened and brownish toward the apex; asci clavate; spores pale, ellipsoid, 12 to 17 μ long and 5 to 8 μ wide.

Collected only in the extreme northern portion of the State, the only undoubted specimens thus far from the shores of Lake Superior. On rocks.

Found in the United States only in the eastern and western mountains and along the north shore of Lake Superior, but extending northward into arctic regions. Also frequent in northern Europe and Asia.

Umbilicaria hyperborea of the preliminary reports.

EXPLANATION OF PLATE 31.—Plant on high rocks, showing the irregularly lobed and jagged thallus. Natural size.

2. *Gyrophora muhlenbergii* Ach. Lich. Univ. 227. pl. 2. f. 11. 1810.

Thallus usually more or less irregular in outline or even lobed, the margin more or less jagged and irregular, middle-sized or large, 5 to 17.5 cm. in diameter (in some specimens found in the State even exceeding 30 cm. in the longest diameter), sometimes more or less perforate, the smooth upper surface more or less reticulately pitted, brown

to olivaceous-brown or blackish, beneath usually darker, papillose and reticulated with perpendicular and horizontal plates of supporting tissue; apothecia commonly in groups, these raised, black and rounded or irregular in outline, convex, 0.75 to 3 mm. in diameter, the apothecia of a group often more numerous than in the last and of about the same size and form; hypothecium pale-brownish or darker; hymenium pale-brownish or pale; paraphyses simple or rarely branched, the apex commonly thickened and brownish; asci clavate; spores hyaline or pale, oblong, 11 to 13 μ long and 4 to 5 μ wide.

Frequent in the northern portion of the State. On rocks.

Distributed throughout the Northern States and British America. Also known in South America and northern Europe.

Umbilicaria muhlenbergii of the preliminary reports.

3. Gyrophora vellea (L.) Ach. Meth. Lich. 109. 1803.

Lichen velleus L. Sp. Pl. 1150. 1753.

Thallus smooth above, variously rounded or irregular in form, the margin usually more or less torn and irregular, rather large-sized, 6.5 to 25 cm. in diameter, considerably thicker and stronger than the two above described, ash-color above, below brown or blackish and clothed with strong rhizoid-like cilia; apothecia commonly in groups, these raised, convex, usually rounded and black, the few seen 1 to 3 mm. in diameter, the individuals frequently much elongated and quite as numerous in the groups as in the last; hypothecium dark brown or rarely paler; hymenium pale or brownish; paraphyses simple or branched, the apices frequently enlarged and brownish; asci cylindrico-clavate; spores hyaline or pale, ellipsoid, 8 to 12 μ long and 5 to 7 μ wide. Seldom fruited.

The plant has about the same distribution in the State as the last, but is by no means so common. On rocks.

In the United States, confined for most part to mountains and to cold shores, but more common throughout British America. Known also in South America and Europe.

Umbilicaria vellea of the preliminary reports.

4. Gyrophora dillenii (Tuck.) Arn. Oesterr. Bot. Zeitschr. 1896: 16. 1896.

Umbilicaria dillenii Tuck. Syn. Lich. N. E. 72. 1848.

Thallus smooth above, irregular in form, and margin much as the last, but the thallus brown and varying toward dark or ashy-brown, never ash-colored, beneath also much as the last, but on the whole of a deeper black, 7 to 32.5 cm. in diameter (our largest species); apothecia usually in convex, more or less orbicular groups of the same general form as in the last, the groups sometimes exceeding 4 mm. in diameter; spores ellipsoid, pale or hyaline, 17 to 25 μ long and 9 to 15 μ wide.

The apothecial and spore characters are taken from Tuckerman, our plant being almost always sterile and no well-fruited specimens being at hand.

Distributed throughout the extreme northern portion of the State and extending as far south as Taylors Falls along the eastern boundary. On rocks.

A strictly North American plant distributed throughout the Atlantic States, though confined to the mountains toward the south. More common throughout the eastern portion of British America.

Umbilicaria dillenii of the preliminary reports.

UMBILICARIA Hoffm. Descr. Pl. Crypt. 1: 7. pl. 2. f. 1-4. 1790.

The thallus is foliose and, like that of *Gyrophora*, is attached to the substratum by an umbilicus. The lower cortex is thickened as in *Gyrophora*, for the same purpose, that of support, and the upper cortex is likewise thin. In our species at least, the mechanical plates are wanting and seem to be replaced by the rings of tissue about the pustules. The algal symbiont is *Cystococcus*.

As in *Gyrophora*, the apothecia frequently occur in groups, and each group is frequently considered a single apothecium. The individual apothecia are usually rounded instead of elongate. The spores are many-celled and muriform, commonly brown, though they may be pale. A single spore usually occupies each ascus, though two sometimes occur together.

The genus has a single representative within the State.

Ours and the other American species occur on rocks.

Type species *Umbilicaria exasperata* (Gunn.) Hoffm. loc. cit.

1. *Umbilicaria pustulata* (L.) Hoffm. Descr. Pl. Crypt. 2: 13. pl. 28. f. 1-2. pl. 29. f. 4. 1794.

Lichen pustulatus L. Sp. Pl. 1150. 1753.

Thallus rounded or irregular in form, the edges more or less irregular and sometimes irregularly lobed, usually of middle size, 3 to 15 cm. in diameter; prominently papulose or pustulate, occurring singly, brown or brownish ash-colored, sometimes more or less powdery, beneath grayish to brownish, granulate, lacunosely pitted; apothecia sometimes single but more commonly in groups, these considerably raised, black and more or less rounded, 0.5 to 2 mm. in diameter, the largest clusters seldom containing more than 12 to 15 apothecia; the individual apothecium usually rounded and concave and when alone reaching 0.5 mm. in diameter, or even 1 mm. in foreign specimens; hypothecium pale brownish to brown; hymenium brownish; paraphyses frequently branched both near the apex and farther back, the apex commonly thickened and brownish; asci broadly-clavate; spores ellipsoid or oblong-ellipsoid, brown or sometimes pale, 48 to 70 μ long and 22 to 38 μ wide.

The subspecies *Umbilicaria pustulata papulosa* (Ach.) Tuck.^a has been recorded for the State, but there are scarcely two distinct forms in Minnesota. Possibly ours is all nearer the subspecies; it surely is so in color, Tuckerman giving ashy gray as the color of the species.

Found throughout the extreme northern portion of the State, but rare. On rocks.

Distributed throughout the eastern side of North America, especially in the mountains. Also in Texas and New Mexico. Known in all of the grand divisions except Australia.

Family LECANORACEAE.

The family as represented in our flora consists of the three genera, *Acarospora*, *Lecanora*, and *Haematomma*. The family thus limited seems natural enough, but is closely related to the *Parmeliaceae*, the close relationship appearing most plainly in the few foliose *Lecanoras*, such as *L. rubina* and *L. muralis*. However, even in these two species, the thallus is closely adnate and scarcely more than subfoliose, while in the *Parmeliaceae* the thalli are always plainly foliose or fruticose.

Thus it appears that the present family is most closely related to the *Parmeliaceae*, and Schneider has seen fit to unite the two families. But there are other relationships of the *Lecanoraceae*, as already mentioned, viz, with the *Baeomycetaceae* through *Icmadophila* and with certain *Lecideaceae* which show some indication of a thalloid exciple.

In the present family the thallus is commonly crustose, but a few of the species of *Lecanora* possess subfoliose thalli. The algal symbiont is commonly *Cystococcus*, but *Pleurococcus* seems to occur instead in the *Acarosporas*. The apothecia vary as to position from sessile to immersed, and the thalloid exciple is plainly evident and commonly persistent in all superficial apothecia. The spores are always hyaline and never muriform, but they vary considerably within these limitations.

The family is large, the genus *Lecanora* being one of the largest in our flora.

^a Syn. Lich. N. E. 70. 1848.

ACAROSPORA Mass. Ric. Lich. 27. *f.* 43-46. 1852.

PLATE 32.

The thallus varies from typically crustose to squamulose or subfoliose forms and is always closely adnate. In most of the species, and in all of ours, there is a good cellular cortex above. The algal and medullary layers are also usually more or less differentiated. The lower portion is scarcely different from the so-called medullary, and, indeed, the whole thallus is frequently more or less distinctly cellular throughout. The algal symbiont is *Pleurococcus*. The attaching organs are rhizoidal hyphæ. The thallus varies greatly in color, white, yellow, greenish, and brown, and even blackish examples occurring.

The apothecia vary considerably in size and appearance, but are always more or less immersed in the thallus, at least in our species. The thalloid exciple is rather poorly developed and tends to disappear in all of our species. The hypothecium is pale and the hymenium of the same color or darker above. The asci vary considerably in form, and the paraphyses are simple or rarely branched. The spores are hyaline, minute, and very numerous in the asci.

The genus is frequently placed with *Lecanora*, but it seems evident enough that species showing such pronounced spore differences should not be referred to that genus. In structure the thallus resembles that of some of the *Lecanoras*, and indeed the cells of the upper cortex are much better differentiated and more distinct in the present genus. However, the spores make it seem possible that there is a close relation between the present genus and *Biatorella*. But the present genus differs from *Biatorella* in having better developed thalli with good upper cortex and in making more or less of a showing of a thalloid exciple. Perhaps the thalloid and excipial development should not count for more than the spores in classification, and it may not, consequently, be unreasonable to suppose that the present genus is more closely related to *Biatorella* than to *Lecanora*.

The genus is not large and is represented in our flora by only four species and subspecies. All occur on rocks, though one has been found on old wood also.

Type species *Acarospora schleicheri* (Ach.) Mass. loc. cit.

EXPLANATION OF PLATE 32.—Fig. 1, *a*, the apothecia; *b*, the thallus on the substratum. Fig. 2; a single apothecium and a small portion of the thallus. Fig. 3, a section of an apothecium and part of the thallus; *a*, the hymenium; *b*, the hypothecium; *c*, the cellular medullary layer. Fig. 4, a section of the thallus; *a*, the upper cortex; *b*, the algal layer; *c*, the cellular medullary layer; *d*, the hyphal rhizoids. Fig. 5, paraphyses and an ascus. Fig. 6, free, simple, and minute spores. Fig. 7, algal cells (*Pleurococcus*), *a*, as they occur in the thallus; *b*, normal size. Fig. 1, natural size; fig. 2, enlarged about 35 diameters; fig. 3, enlarged 400 diameters; fig. 4, enlarged 300 diameters; figs. 5 and 6, enlarged 650 diameters; fig. 7, enlarged: *a*, 650 diameters; *b*, 500 diameters. From Schneider.

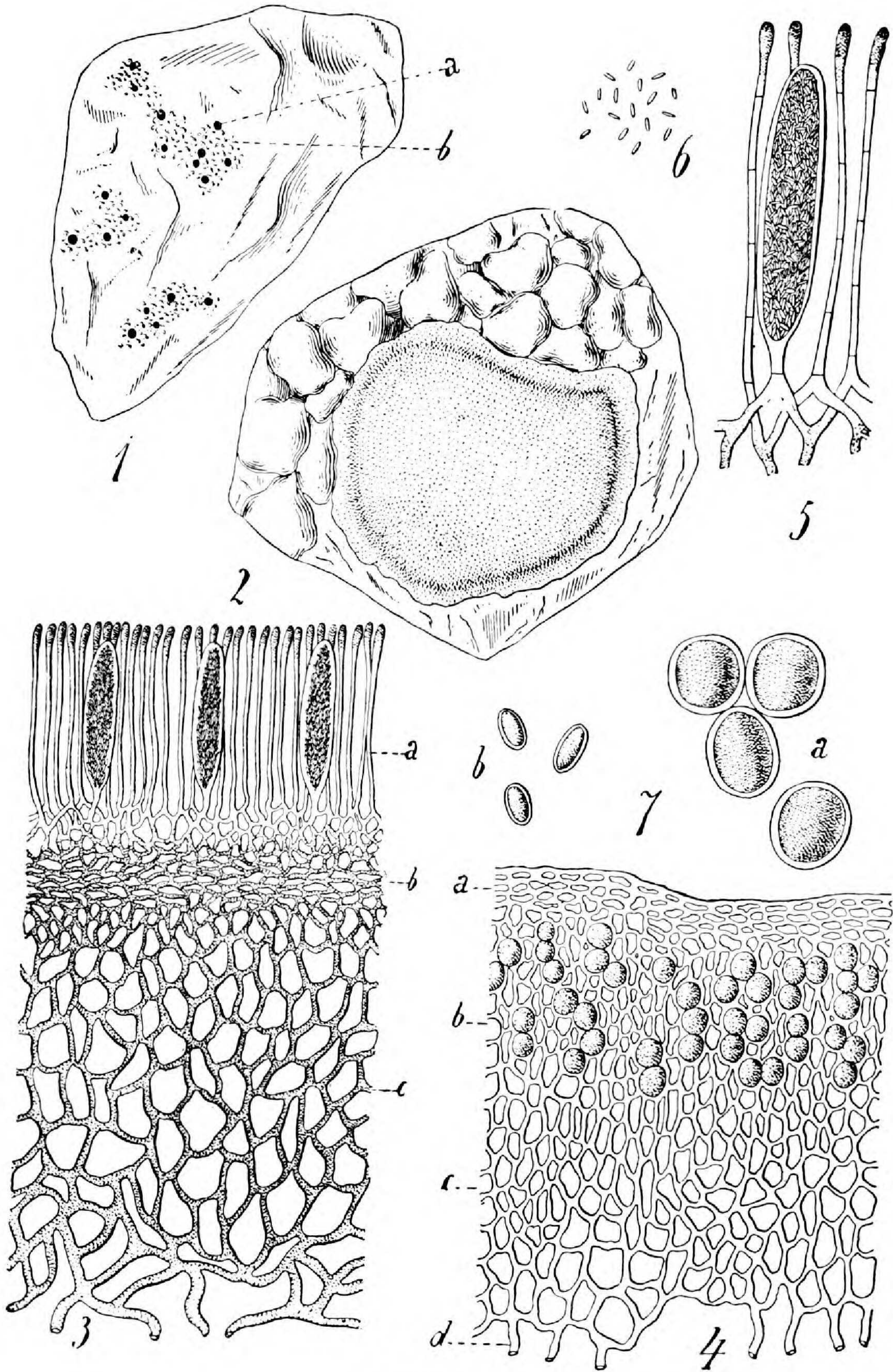
KEY TO THE SPECIES.

- | | | |
|---|-----|----------------------------------|
| Thallus lemon-yellow..... | 1. | <i>A. xanthophana</i> . |
| Thallus yellowish brown to chestnut, or rarely ashy white. | | |
| Squamules scattered and usually plainly lobed; thallus yellowish brown to chestnut..... | 2b. | <i>A. cervina fuscata</i> . |
| Squamules usually compacted into an areolate crust, not conspicuously lobed. | | |
| Thallus yellowish brown to chestnut..... | 2. | <i>A. cervina</i> . |
| Thallus ashy white..... | 2a. | <i>A. cervina cinereo-alba</i> . |

1. *Acarospora xanthophana* (Nyl.) Fink.

Lecanora xanthophana Nyl. Ann. Sci. Nat. Bot. IV. 15: 379. 1862.

Thallus composed of peltate or round-lobulate squamules, which are usually compacted, except about the margin of the thallus, into an angulate-areolate crust, the



AN ACAROSPORA.

areoles or squamules flat or rarely more or less convex and of moderate size, 0.3 to 2 mm. across, lemon-yellow, the upper cortex present, distinctly cellular, as is the whole thallus, the squamules sometimes scattered; apothecia small or minute, 0.2 to 0.5 μ in diameter (said to be sometimes larger), immersed, the disk flat or somewhat concave, frequently somewhat irregular and reddish brown or rarely blackish, the thalloid exciple usually evident and entire; hypothecium pale; hymenium of same color, or darker above; paraphyses simple or rarely branched, frequently somewhat enlarged and brownish toward the apex; asci clavate, cylindrico-clavate, or somewhat irregular; spores ovoid, 3 to 3.5 μ long and 1.5 to 2 μ wide.

The plant has been collected in such widely separate portions of the State as Minneapolis, Battle Lake, and several localities in the southwestern part. On rocks other than calcareous

Generally distributed over the United States and northward into British America. Known also in South America and Africa.

Lecanora xanthophana of the preliminary reports.

2. *Acarospora cervina* (Wahl.) Koerb. Syst. Lich. 154. 1855.

Lichen cervinus Wahl. Fl. Lapp. 421. 1812.

Thallus composed of subpeltate or crenate-lobate squamules, which are closely adnate and may be scattered or more commonly compacted into an areolate crust, the areoles or squamules rather smaller than those of the last, commonly flat and rarely imbricate, yellowish brown (cervine) to dark chestnut; microscopic structure as in the last; apothecia much as in the last, but rather larger and sometimes becoming adnate, the thalloid exciple perhaps disappearing more often; hypothecium pale; hymenium of same colors or brownish above; paraphyses slender, simple or rarely branched, usually slightly enlarged and brownish toward the apex; asci ventricose or cylindrico-clavate; spores oblong to subspherical, 3 to 5 μ long and 1 to 2 μ wide in the oblong forms.

Generally distributed over the State. On rocks other than calcareous.

Throughout North America, except the Southern States and southward. Found also in Europe and Africa.

Lecanora cervina (Pers.) Nyl. of the preliminary reports.

2a. *Acarospora cervina cinereoalba* Fink, Minn. Bot. Stud. 2: 319. 1899.

Thallus ashy or ashy-white. Otherwise as the species.

Collected at Mankato and at Granite Falls. On granite with the usual form of the species.

A North American form not known elsewhere.

Lecanora cervina cinereoalba of the preliminary reports.

2b. *Acarospora cervina fuscata* (Schrad.) Fink.

Lichen fuscatus Schrad. Spic. Fl. Germ. 83. 1794.

Thallus inclined to more squamulose and lobed conditions, the squamules rather larger and often scattered; apothecia rather smaller and sometimes punctiform; spores said to be larger (Nylander).

Usually regarded as a distinct species.

No doubt generally distributed over the State, but very difficult to distinguish. On rocks.

North American distribution much as that of the species. Known also in South America, Europe, and Africa.

Lecanora fuscata and subspecies *rufescens* of the preliminary reports.

LECANORA Ach. Lich. Univ. 77, 344. pl. 7. f. 3-7. 1810.

The thallus varies from foliose or subfoliose to strictly crustose forms, the latter being the more common and representative thalli of the genus. In the best developed thalli the whole structure is nearly or quite as closely adnate as in the more

typically crustose species. Some lichenists, however, admit to the genus plants having fruticose thalli. In our foliose species there is a well-developed upper cortex, which is much gelatinized and seems to be most commonly composed of hyphæ rather than pseudocellular. In these the lower cortex is similar but commonly thinner, or sometimes scarcely at all developed. In these foliose species the algal and medullary layers are also well developed, while rhizoids are few or entirely absent. The better-developed crustose forms show some suggestion of an upper cortex and algal and medullary layers, but the great majority of them do not; in the latter there are found the simple hyphal rhizoids as attaching organs. *Cystococcus* is the algal symbiont.

The apothecia are commonly of medium size, usually sessile, though adnate and immersed forms occur. The thalloid exciple is commonly somewhat raised, though it may disappear entirely, leaving a biatoroid apothecium. The exciple is most commonly entire or crenate and the disk flat or slightly convex. The hypothecium is pale or only slightly colored, and the hymenium is of the same color, or darker above. The asci are clavate, as a rule, and the paraphyses commonly simple, though compound forms may doubtless be found in any of the species. The spores are simple, but vary greatly as to size and form.

The foliose species are sometimes placed in another genus, but there is a gradual transition to the crustose forms, which may be represented to some extent, at least externally, in the most foliose species, and for this reason it has not seemed best to attempt a division. As to thallus structure, the genus is as a whole most closely related to *Haematomma* and *Acarospora*, and only less closely with some of the better-developed *Lecideas*. Also, there is a not very remote relationship between the present genus and the one last named as to spores and apothecial structure, transitional forms between thalloid and lecideoid exciples occurring in both genera. *Lecanora* shows also affinities with *Parmelia*.

Some forty forms occur in the State. Mostly on trees and rocks.

Type species *Lecanora tartarea* (L.) Ach. loc. cit.

KEY TO THE SPECIES.

Section I. Thallus usually lobed at the circumference (as also in two species of Section II).

Thallus rather thick and often scattered, greenish straw-colored.

- | | |
|--|-------------------------------------|
| Apothecia pale yellow to yellowish brown..... | 1. <i>L. rubina</i> |
| Apothecia of the same color as the thallus or pale brown.... | 1a. <i>L. rubina heteromorpha</i> . |

Thallus thinner, smaller, and more compact.

Thallus some other color than sea green.

- | | |
|---|------------------------------------|
| Thallus light-colored and sometimes white-powdery, often breaking away at the center or one side..... | 2b. <i>L. muralis versicolor</i> . |
|---|------------------------------------|

- | | |
|--|-----------------------------------|
| Thallus becoming yellowish brown or reddish brown; the lobes short and often black-margined..... | 2d. <i>L. muralis diffracta</i> . |
|--|-----------------------------------|

Thallus sea-green.

- | | |
|-----------------------------------|----------------------------------|
| Thallus lobes much flattened..... | 2a. <i>L. muralis saxicola</i> . |
|-----------------------------------|----------------------------------|

Thallus lobes not so much flattened.

- | | |
|--|------------------------------------|
| Thallus lobes somewhat elongated..... | 2. <i>L. muralis</i> . |
| Thallus lobes much elongated and flexuous..... | 2c. <i>L. muralis garovaglii</i> . |

Section II. Thallus not lobed (except in nos. 5 and 16).

Spores often more than 20 μ in length.Spores reaching 50 μ in length.Thallus thick and rough..... 15. *L. tartarea*.

Thallus thinner.

Thallus smoothish; apothecia large, flesh-colored or white-pruinose..... 14. *L. pallescens*.Thallus verrucose, chinky or subareolate; apothecia small or minute, black..... 17. *L. mutabilis*.Spores not reaching 50 μ in length.

Apothecia immersed, or becoming adnate.

Apothecia always becoming adnate, disk black, exciple entire..... 18b. *L. cinerea gibbosa*.

Apothecia sometimes becoming adnate.

Disk light brown or darker, commonly white-pruinose..... 19. *L. calcarea*.Disk of same color as above, not pruinose, but frequently punctiform..... 19a. *L. calcarea contorta*.

Apothecia always immersed.

Thallus ashy to brownish.

Thallus thick and becoming areolate; disk black, medium-sized..... 18. *L. cinerea*.Thallus thinner, never becoming areolate; disk usually minute or irregular..... 18a. *L. cinerea laevata*.

Thallus finally darker-colored.

Thallus ashy to olivaceous; disk reddish or brownish; plant found on rocks frequently wet..... 20. *L. lacustris*.Thallus blackish-olivaceous..... 18c. *L. cinerea microspora*.Spores never surpassing 20 μ in length.

Apothecia always sessile, or varying in position from sessile to adnate.

Apothecia always sessile; disk dark; exciple entire or subcrenulate; margin of the thallus usually lobed.... 5. *L. frustulosa*.

Apothecia either sessile or adnate.

Disk whitish buff or more or less whitish-pruinose.

Exciple entire and usually regular..... 3. *L. pallida*.Exciple angulate and variously irregular..... 3a. *L. pallida angulosa*.

Disk light brown to black.

Thallus quite thick and more or less imbricate-lobed. 16. *L. melanaspis*.

Thallus not lobed.

Thallus thick and rough, areolate or verrucose.

Exciple persistent.

Exciple often flexuous, entire, or crenate..... 7a. *L. subfusca allophana*.Exciple scarcely ever flexuous, entire, or crenate..... 7. *L. subfusca*.Exciple frequently disappearing..... 7b. *L. subfusca campestris*.

- Thallus not so thick, sometimes granulose.
 Thallus granulose, or becoming verrucose.
 Thallus granulose and sorediate..... 7g. *L. subfusca sorediifera*.
 Thallus granulose, becoming verrucose..... 7c. *L. subfusca hypnorum*.
- Thallus smooth or chinky.
 Exciple entire.
 Apothecia small, usually brown..... 7d. *L. subfusca argentata*.
 Apothecia small, usually black..... 7e. *L. subfusca coilocarpa*.
 Exciple subentire; apothecia flesh-colored or pale brown, small or minute..... 7f. *L. subfusca distans*.
- Apothecia always adnate, or varying in position from adnate to immersed.
 Apothecia always adnate.
 Exciple usually crenate or crenulate.
 Disk gray-pruinose..... 8. *L. hageni*.
 Disk not gray-pruinose.
 Disk brown to blackish; spores sometimes 2-celled 13. *L. erysibe*.
 Disk yellowish brown to olivaceous..... 9. *L. dispersa*.
- Exciple scarcely ever plainly crenate or crenulate.
 Exciple entire, flexuous, or rarely subcrenulate.
 Exciple becoming flexuous or rarely disappearing, disk dark grayish or yellowish..... 12. *L. polytropa*.
 Exciple persistent, entire or subentire; disk flesh-colored to light brown..... 10. *L. sambuci*.
 Exciple irregular or disappearing; disk flesh-colored to brownish..... 21. *L. subepulotica*.
- Apothecia adnate or more or less immersed.
 Disk always black, or becoming black.
 Disk always black; exciple usually entire..... 4. *L. atra*.
 Disk becoming black.
 Disk more or less pruinose.
 Disk at first flesh-colored..... 6. *L. sordida*.
 Disk at first reddish-olivaceous..... 11b. *L. varia saepincola*.
 Disk not pruinose, flesh-colored to blackish; exciple entire or disappearing..... 11a. *L. varia symmicta*.
- Disk never black.
 Disk flesh-colored to yellowish buff; exciple entire or crenulate..... 11. *L. varia*.
 Disk dark grayish or yellowish; exciple becoming flexuous and disappearing..... 12a. *L. polytropa melana*.

1. *Lecanora rubina* (Lam. & DC.) Ach. Lich. Univ. 412. 1810.

Lichen rubinus Lam. & DC. Fl. Fr. ed. 3. 1: 77. 1778.

Thallus commonly closely adnate and subfoliose but rarely plainly foliose, submonophyllous and attached by an umbilicus; the former condition more or less rounded, irregular or suborbicular, 15 to 30 mm. in diameter, the lobes sometimes becoming elongated, frequently imbricated or more often closely aggregated into an appar-



LECANORA MURALIS VERSICOLOR (PERS.) TUCK.

ently areolate crust, this sometimes radious at the circumference; or rarely reduced to scattered, closely adnate, flattened or hemispherical squamules, greenish straw-colored above, beneath commonly black; apothecia scattered or rarely clustered, middle-sized or large, 1.5 to 5 mm. in diameter, sessile or adnate, pale yellow to reddish brown, the thalloid margin thin, flexuous, and sometimes disappearing, the disk usually flat, convex or variously irregular; hypothecium pale or pale yellowish; hymenium pale below and commonly somewhat colored above; paraphyses simple or rarely branched, usually enlarged and colored toward the apex; asci clavate; spores ellipsoid, 7 to 15 μ long and 4.5 to 8 μ wide.

Generally distributed over the State. On rocks other than calcareous.

The plant is generally distributed in North America, but mostly confined to the mountains southward. Known also in South America, Europe, and Asia.

1a. *Lecanora rubina heteromorpha* Ach. Lich. Univ. 412. 1810.

Thallus somewhat chinky or wrinkled, in ours less inclined to distinctly lobed conditions; apothecia of the same color as the thallus or becoming pale brown.

Probably as widely distributed in the State as the species, though not so common and less often observed. Habitat the same as above.

Elsewhere in North America from Texas, Oregon, and Iowa. Known also in Europe.

2. *Lecanora muralis* (Schreb.) Tuck. Gen. Lich. 113. 1872.

Lichen muralis Schreb. Spic. Fl. Lips. 130. 1771.

Thallus closely adnate, subfoliose, lobed and the lobes usually somewhat elongated and sinuately divided toward the margins, the central portions commonly more or less crenate-scaly or areolate, on the whole thinner and more closely attached than that of the last, and likewise frequently tending to pass into poorly developed conditions, the best developed forms usually suborbicular, 10 to 60 mm. in diameter; commonly sea-green, the cortical layers composed of closely packed hyphæ, or the upper perhaps sometimes pseudocellular, the lower very thin; apothecia small to middle-sized, 0.65 to 2 mm. in diameter, adnate or rarely somewhat immersed, the disk flat or somewhat concave, pale yellowish to tawny brown, the thalloid exciple entire, flexuous or crenate; hypothecium pale; hymenium pale below, and frequently somewhat brownish above; paraphyses commonly simple, frequently enlarged and brownish toward the apex; asci clavate; spores ellipsoid, 9 to 15 μ long and 4.5 to 7 μ wide.

Tuckerman's view has been followed in disposing of the present species and its subspecies. Europeans commonly group the subspecies about the next form.

The plant is generally distributed over the State, usually as one of the subspecies below. On rocks.

Distributed throughout North America in one form or another. Known also in all of the grand divisions, most commonly as the first subspecies below.

2a. *Lecanora muralis saxicola* (Poll.) Tuck. Syn. N. A. Lich. 1: 184. 1882.

Lichen saxicola Poll. Hist. Pl. Palat. 3: 225. 1777.

Form with the thallus lobes much flattened, and normally colored. Our most common subspecies.

Generally distributed over the State. On rocks other than calcareous.

The most widely distributed North American form. Known also in all of the grand divisions.

2b. *Lecanora muralis versicolor* (Pers.) Tuck. Syn. N. A. Lich. 1: 185. 1882.

PLATE 33.

Lichen versicolor Pers. Ann. Bot. Usteri 7: 24. 1794.

Thallus smaller and frequently breaking away at one side or in the center, frequently several thalli closely packed together and even overlapping more or less,

lighter-colored and sometimes more or less white-powdery; apothecia smaller, more inclined to immersed conditions, the exciple usually entire.

Collected at Mankato and at Battle Lake. On limestones. No doubt occurs on the same rocks in other portions of the State, especially in the southeastern portion.

Elsewhere in North America in Iowa, Nebraska, Missouri, Kansas, and Newfoundland. Known also in Europe.

EXPLANATION OF PLATE 33.—Plant on rocks, showing the fairy ring formation characteristic of this subspecies. Natural size.

2c. *Lecanora muralis garovaglii* (Koerb.) Tuck. Syn. N. A. Lich. 1: 184. 1882.

Placodium garovaglii Koerb. Par. Lich. 54. 1865.

Thallus lobes elongated, flexuous, convex, plicate-radious, normally colored.

Collected at Koochiching on the northern boundry of the State. On rocks.

Known elsewhere in North America in Nebraska, Nevada, and Newfoundland. Found also in Europe and Africa.

2d. *Lecanora muralis diffracta* (Ach.) Tuck. Syn. N. A. Lich. 1: 184. 1882.

Lichen diffractus Ach. Lich. Succ. 63. 1798.

Thallus darker, usually yellowish brown or reddish brown, central areoles scattered more or less and frequently black-margined, the lobes of the margin short.

Collected at Grand Portage, on Mount Josephine. On rocks. The material referred to here is uncertain.

Elsewhere in North America in California. Known also in Europe. ’

3. *Lecanora pallida* (Schreb.) Schaer. Enum. Lich. Eur. 78. 1850.

Lichen pallidus Schreb. Spic. Fl. Lips. 133. 1771.

Thallus crustose, neither lobed nor in any degree foliose, but closely adnate and, like the other crustose species, attached by hyphal rhizoids, usually thin and smooth, but becoming thicker and chinky or somewhat verrucose, whitish or pale cream-colored and darkening, cortical layer scarcely developed, usually somewhat irregular in form and 5.5 to 10 cm. across, or even more widely spread; apothecia sessile or more commonly adnate, small to middle-sized, 0.7 to 3 mm. in diameter, the disk whitish buff and white-pruinose, flat, with a thick and entire exciple, or becoming convex and sometimes irregular, and the margin rarely disappearing or more commonly becoming flexuous; hypothecium pale; hymenium pale throughout or somewhat brownish above; paraphyses commonly simple and more or less gelatinized, frequently enlarged and brownish above; asci clavate; spores ellipsoid, 7 to 15 μ long and 5 to 8 μ wide.

Thus far collected only in the northern portion of the State, but the plant occurs in northern Iowa and doubtless also farther south in Minnesota. On trees.

Generally distributed throughout North America. Known in all of the grand divisions.

3a. *Lecanora pallida angulosa* (Schreb.) Koerb. Syst. Lich. 145. 1855.

Lichen angulosus Schreb. Spic. Fl. Lips. 136. 1771.

Apothecia becoming crowded with angulate and variously irregular exciple, the disk rather more darkly subpruinose.

In our single specimen the exciple is persistent and the thallus rather thick and subverrucose or chinky-subareolate. The specimen was collected at Duluth by Anna M. Kimball and has not otherwise been reported from the State. On trees.

Scarcely referred to in North America lists except in a general way in Tuckerman's Synopsis, but no doubt quite widely distributed. Known also in Europe and Africa.

4. *Lecanora atra* (Huds.) Ach. Lich. Univ. 344. 1810.

Lichen ater Huds. Fl. Angl. 445. 1762.

Thallus crustose and of moderate thickness, composed of granules which usually run together into a smoothish or more commonly verrucose or areolate crust, occurring

in suborbicular patches, 2 to 6.5 cm. in diameter or more commonly irregularly and more widely spread over the substratum, sea-green varying toward whitish ash-color, scarcely corticate; apothecia small to middle-sized, 0.9 to 2 mm. in diameter, adnate or more or less immersed, the disk very black, flat or somewhat convex, the exciple entire or rarely flexuous or crenulate, very rarely disappearing, and occasionally blackening; hypothecium and hymenium brown or blackish brown, or appearing black under a hand lens; paraphyses somewhat coherent, but apparently simple, usually somewhat colored throughout, and darker and thicker toward the apex; asci clavate; spores ellipsoid, 10 to 15 μ long and 5 to 7 μ wide.

The plant is difficult to distinguish from the next species and from *Lecanora sub-usca coilocarpa*, but the dark hymenium and hypothecium serve to differentiate it.

Collected at Taylors Falls. On the igneous rocks.

Generally distributed throughout North America. Known also in all of the grand divisions.

5. *Lecanora frustulosa* (Dicks.) Ach. Lich. Univ. 405. 1810.

Lichen frustulosus Dicks. Pl. Crypt. Brit. 3: 13. pl. 8. f. 1. 1793.

Thallus crustose and rather thick, the central portions areolate or verrucose-areolate, the areoles or verrucæ much raised and irregular (globose-frustulose) or even subsquamulose, the margin usually more plainly squamulose and subfoliose, commonly suborbicular, covering considerable areas of the substratum, usually 2.5 to 10 cm. in diameter, the areoles somewhat scattered, or more commonly crowded and subimbricate; sea-green varying toward ashy or yellowish, sometimes showing a cellular cortex, and the algal and medullary layers frequently quite distinct; apothecia small to middle-sized, 1 to 2 mm. in diameter, sessile, the disk flat or somewhat convex, reddish brown to black, the exciple persistent or rarely disappearing, entire or subcrenate; hypothecium pale; hymenium pale below and brownish above; paraphyses simple or rarely branched, commonly enlarged and brownish toward the apex; asci clavate; spores ellipsoid, 9 to 15 μ long and 5 to 7.5 μ wide.

Distributed throughout the northern portion of the State and also found on the granitic rock exposures of the Minnesota River valley, there collected at Redwood Falls and at Granite Falls. On rocks other than calcareous.

Elsewhere in North America in Greenland, New England, South Dakota, Colorado, and California. Known also in Europe and Asia.

6. *Lecanora sordida* (Pers.) Th. Fr. Nov. Act. Soc. Sci. Ups. III. 3: 215. 1861.

Lichen sordidus Pers. Ann. Bot. Usteri 7: 26. 1794.

Thallus crustose, rarely unbroken, but more commonly chinky or areolate, rather smooth or the areoles somewhat raised and irregular, usually widely and irregularly spread over the substratum, the margins sometimes obscurely subsquamulose, scarcely corticate, commonly whitish varying toward gray or rarely brownish; apothecia usually small, 0.75 to 1.5 mm. in diameter, adnate or more or less immersed, the disk flat or convex, flesh-colored to black but whitish-pruinose, the exciple entire and rarely disappearing; hypothecium pale; hymenium pale beneath and commonly more or less brownish above; paraphyses simple or rarely branched, commonly enlarged and brownish toward the apex; asci clavate; spores ellipsoid, 7 to 14 μ long and 5 to 7 μ wide.

Collected in the northeastern portion of the State at Grand Portage, at South Fowl Lake, and in the Misquah Hills. On high bluffs.

Distribution in North America essentially the same as that of the last species above, but the present species has been met in New York and at several places in British America. Known also in all of the grand divisions except Australia.

7. **Lecanora subfusca** (L.) Ach. Lich. Univ. 393. *pl.* 7. *f.* 6. 1810. FIGURE 14.
Lichen subfuscus L. Sp. Pl. 1142. 1753.

Thallus crustose, rather smooth, or becoming chinky or verrucose-areolate, usually of moderate thickness, but rarely thin, with the granules somewhat scattered, occurring in suborbicular patches, from 1.5 cm. upward in diameter, or irregular and frequently widely spread over the substratum, sea-green varying to ashy or whitish, without other cortical structure than a gelatinized and often structureless mass of hyphæ; apothecia

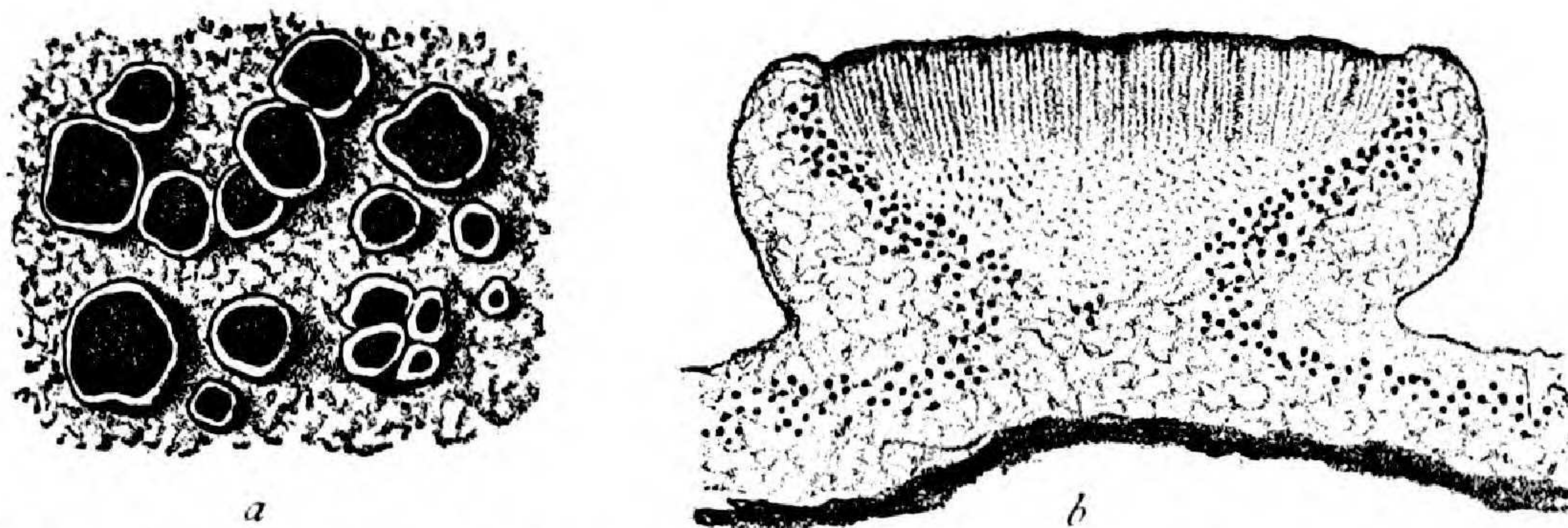


FIG. 14.—*Lecanora subfusca*. *a*, Thallus with several apothecia; *b*, a section of an apothecium to show the thalloid exciple, the hymenium and the hypothecium; *a*, Enlarged 3 diameters; *b*, 60 diameters. From Reinke.

small to middle-sized, sessile or adnate, 0.5 to 2 mm. in diameter, the disk flat to somewhat convex, light brown to black in color, the exciple entire to crenate and always persistent; hypothecium pale; hymenium pale below and usually pale brownish above; paraphyses simple or rarely branched, sometimes enlarged and brownish toward the apex; asci variously clavate; spores ellipsoid, 9 to 20 μ long and 6 to 10 μ wide.

Generally distributed over the State, as are some of the subspecies given below. On trees or dead wood, or rarely on rocks.

Known throughout North America. Found also in all of the grand divisions.

- 7a. **Lecanora subfusca allophana** Ach. Lich. Univ. 395. 1810.

Thallus rather thick, rough or granulate-verrucose; apothecia reaching the full size of the species, the disk reddish brown to blackish, the exciple entire, flexuous, or crenate; spores reaching full size for the species.

In this and the other subspecies we have followed Tuckerman.

Distributed throughout the northern portion of the State. On cedars in swamps.

Though the subspecies is not recorded for a large number of North American localities, it is no doubt widely distributed. Known also in South America, Europe, and Africa.

- 7b. **Lecanora subfusca campestris** Schaer. in Rabenh. Lich. Exsicc. 691. 1860.

Thallus becoming thick and roughened; apothecia finally and often irregularly convex and the exciple frequently disappearing, wholly or in part.

Collected at Minneapolis and at Granite Falls; not previously reported from the State. On rocks.

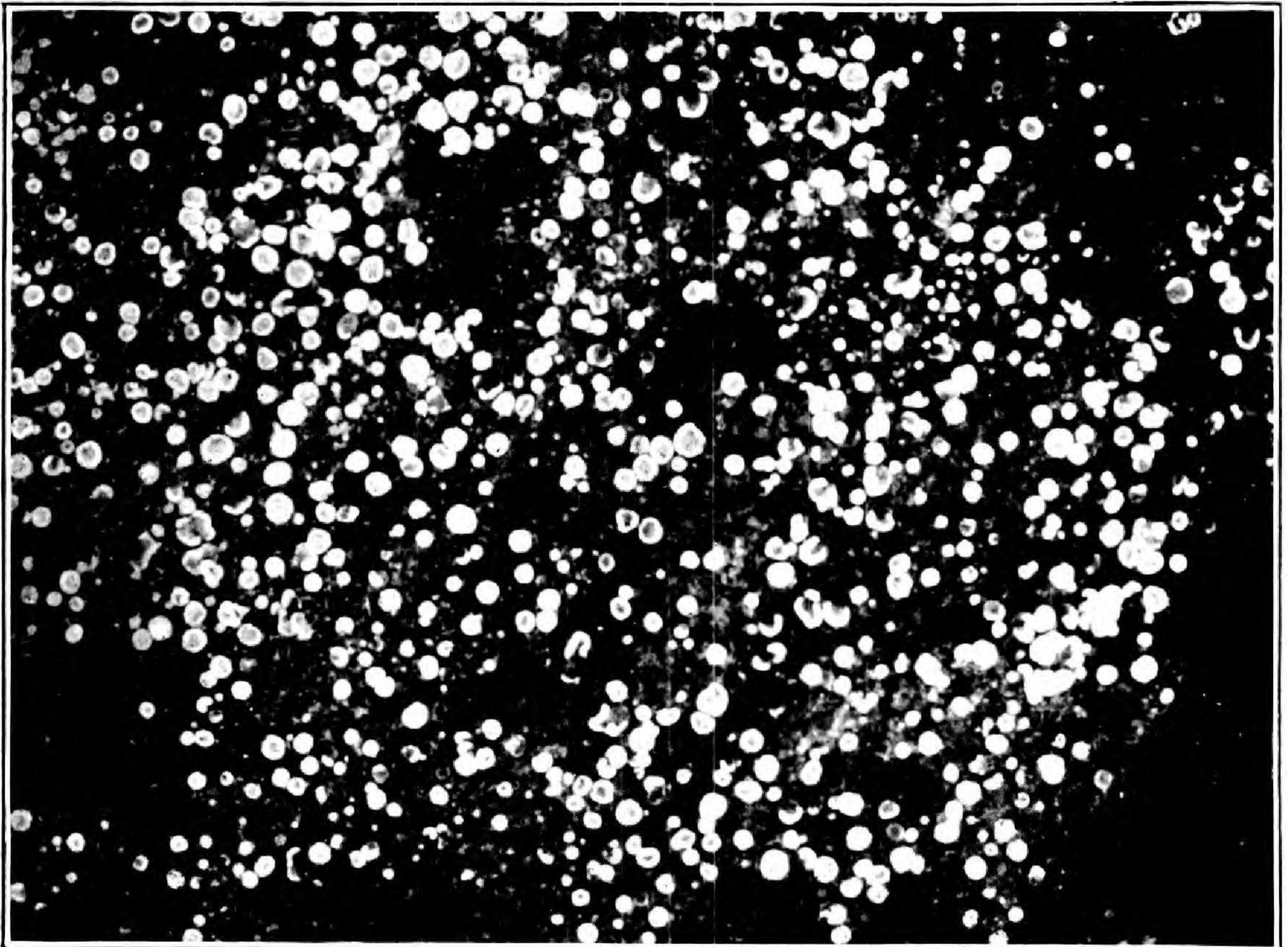
Elsewhere in North America in California. Known also in Europe, Asia, Africa, and New Zealand.

- 7c. **Lecanora subfusca hypnorum** (Wulf.) Schaer. Enum. Lich. Eur. 75. 1850.

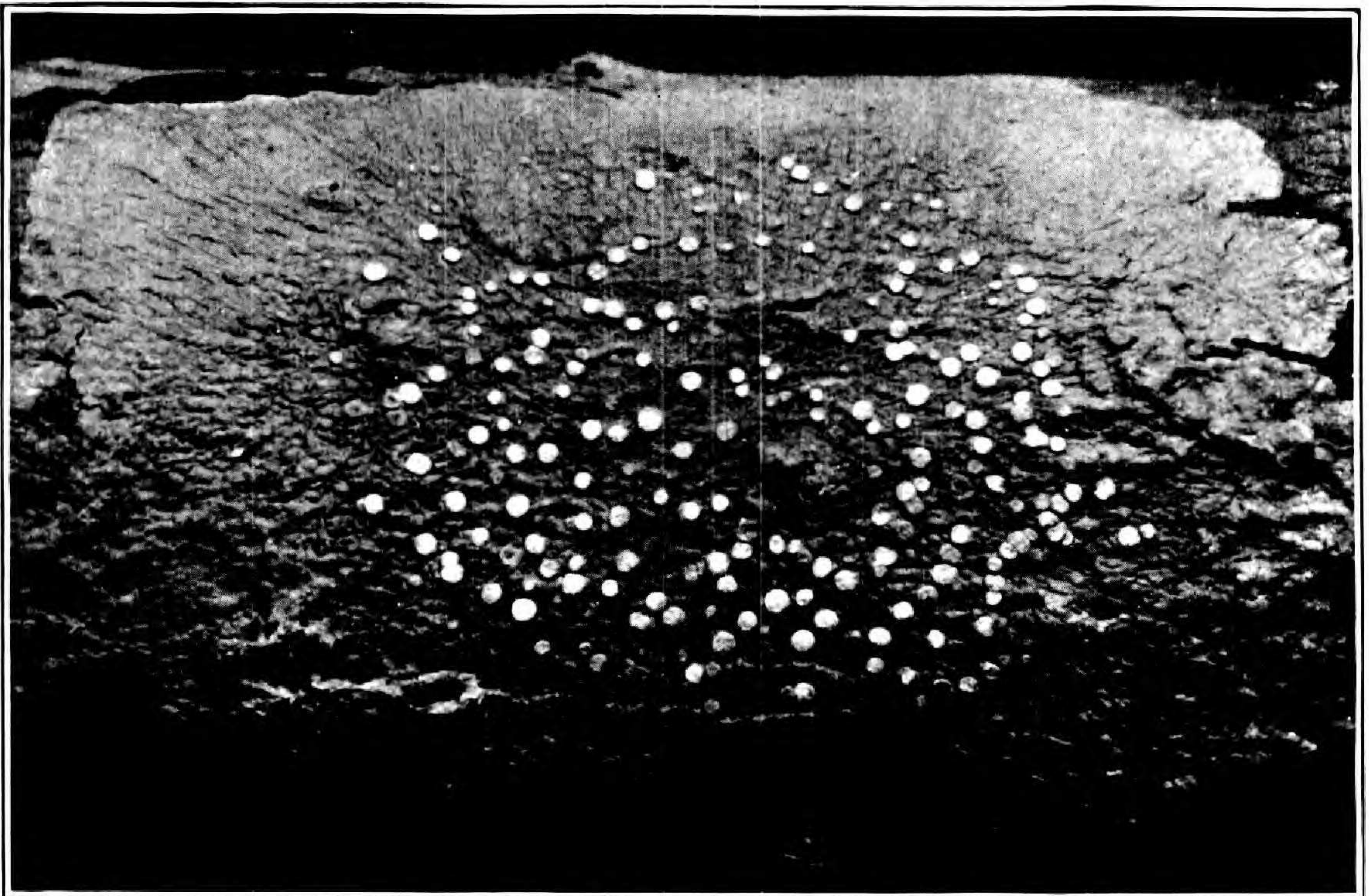
Lichen hypnorum Wulf. in Jacq. Coll. Bot. 4: 233. *pl.* 7. *f.* 2. 1790.

Thallus running over mosses, granulose or verrucose, whitish; apothecia middle-sized, brown, the exciple entire or flexuous.

The plant placed here was collected in the Misquah Hills. Among moss on a cedar tree.



A. *LECANORA HAGENI* ACH.



B. *PERTUSARIA VELATA* (TURN.) NYL.

The plant is definitely reported from various points in British America. Thus apparently arctic or alpine. Known also from northern Europe and Asia.

7d. *Lecanora subfusca argentata* Ach. Lich. Univ. 393. 1810.

Parmelia subfusca argentata Ach. Meth. Lich. 169. 1803.

Thallus rather thin and smooth, whitish; apothecia smaller, scarcely ever exceeding 1.5 mm. in diameter, the exciple usually entire; spores rather small.

Generally distributed over the State. On trees. Probably the most common subspecies, though less easily noted than the next.

Though seldom recorded, no doubt generally distributed over North America. Known also in South America and Europe.

7e. *Lecanora subfusca coilocarpa* Ach. Lich. Univ. 393. 1810.

Thallus rather thin, but becoming more or less granulose and chinky, whitish; apothecia rather small, scarcely exceeding 1.25 mm. in diameter, flat or slightly concave, the disk black and the exciple usually entire. The whole structure may become coarser, with larger apothecia, the black disk being still present.

The most noticeable subspecies and generally distributed over the State. On trees and more rarely on rocks.

No doubt occurring in all portions of North America. Known also in South America and Europe.

7f. *Lecanora subfusca distans* (Ach.) Nyl. Not. Sällsk. Faun. Flor. Fenn. 5:160. 1861.

Parmelia distans Ach. Meth. Lich. 168. 1803.

Thallus thin and whitish; apothecia small or minute, 0.5 to 1 mm. in diameter, the disk pale brown or flesh-colored, the exciple subentire or obscurely crenulate; spores the smallest of the species.

The plant was collected at Mankato. On sandstone, but doubtless occurring elsewhere in the State on trees. Easily passed over for a Lecidea or Rinodina.

Like the other subspecies, not often noted, yet doubtless widely distributed in North America. Known in all of the grand divisions.

7g. *Lecanora subfusca soreidiifera* Th. Fr. Lich. Scand. 1: 239. 1859.

Thallus commonly verrucose, breaking more or less into conspicuous whitish soredia; apothecia rather small, absent or few, the exciple entire or obscurely crenulate; said to disappear sometimes.

Generally distributed over the northern portion of the State. On trees. Also occurs farther south in the State and in Iowa, but has thus far been met only in the sterile condition.

Apparently not noted elsewhere in North America. Known in Europe.

Lecanora variolascens is the synonym of the preliminary reports.

8. *Lecanora hageni* Ach. Lich. Univ. 367. 1810.

PLATE 34, A.

Lichen hageni Ach. Lich. Suec. 57. 1798.

Thallus crustose, smooth and thin, but passing into leprose-verrucose or verrucose conditions, limited in size or widely spread over the substratum, the scales or verrucæ sometimes more or less scattered or the whole thallus disappearing, without definite cortex, dirty-greenish, ashy or whitish; apothecia small or minute, 0.4 to 1 mm. in diameter, commonly flat, thin and adnate, the disk from pale brown to blackish and sometimes more or less gray-pruinose, the exciple usually whitish and almost always more or less crenate, rarely flexuous or disappearing; hypothecium pale or slightly brownish; hymenium pale throughout or brownish above; paraphyses simple or rarely branched, sometimes slightly enlarged and darker toward the apex; asci clavate; spores oblong-ellipsoid, 7 to 14 μ long and 4 to 6 μ wide.

A variable lichen. A rather large-fruited form, collected on limestone at St. Cloud by Mr. Arthur Morgan, has been referred by Dr. A. Zahlbruckner to *Lecanora dispersa*. This plant, however, seems quite as much at home with the present species and in some respects appears quite like certain forms of *Lecanora subfusca*.

The species is generally distributed over the State. On rocks and old wood.

Distributed throughout North America. Known also in Europe and Asia.

EXPLANATION OF PLATE 34.—A, Plant of *Lecanora hageni* on rocks, showing the apothecia. B, Plant of *Pertusaria velata* on branch of tree, showing the crustose thallus and the apothecia. A enlarged $1\frac{1}{2}$ diameters; B, $1\frac{3}{4}$ diameters.

9. *Lecanora dispersa* (Pers.) Floerke, Deutsch. Lich. 3: 4. 1815.

Lichen dispersus Pers. Ann. Bot. Usteri 7: 27. 1794.

Thallus of scattered and small and inconspicuous dirty greenish or whitish scales or granules, or entirely disappearing, or in a form on limestone, continuous beneath the clustered apothecia, these covering areas from 5 to 20 mm. in diameter; apothecia also scattered or more rarely clustered, commonly minute, but sometimes larger, 0.4 to 1.5 mm. in diameter, adnate, when crowded more or less angular, the disk flat, yellowish-brown to olivaceous, the exciple much as in the last, sometimes more or less pruinose and more inclined to entire conditions; hypothecium pale; hymenium pale below and commonly somewhat darkened above; paraphyses simple or rarely branched, quite inclined to cohere, sometimes slightly enlarged and darker toward the apex; asci clavate; spores ellipsoid, 8 to 12 μ long and 3.5 to 5.5 μ wide, thus somewhat smaller than in the European plants examined.

Closely related to the last above, but generally regarded as a distinct species.

Collected at Warroad, at Le Clair, and at Rainy Lake City. On old wood. A plant from the limestone at St. Cloud has been referred here by Doctor Zahlbruckner. See note under *Lecanora hageni*.

Elsewhere in North America in Labrador or Newfoundland. Known also in Europe, Asia, Africa, and New Zealand.

10. *Lecanora sambuci* (Pers.) Nyl. Not. Sällsk. Faun. Flor. Fenn. 5: 168. 1861.

Lichen sambuci Pers. Ann. Bot. Usteri 7: 26. 1794.

Thallus crustose and rather thin, smooth or passing into granulose or subleprose conditions, spread over the substratum in rather large and usually irregular patches, 35 to 90 mm. across, whitish or ashy in color, in ours the crust continuous and usually conspicuous by its color, but said sometimes to disappear almost entirely; apothecia small or minute, 0.5 to 1 mm. in diameter, adnate, the disk flat or convex, flesh-colored to light brown, the exciple white or whitish, in ours entire or subentire and rarely disappearing, said to be crenulate in European specimens; hypothecium pale; hymenium pale throughout or somewhat brownish above; paraphyses simple or rarely branched, sometimes slightly enlarged and darker toward the apex; asci clavate or ventricose-clavate; spores ellipsoid, 8 to 12 μ long and 5 to 7 μ wide, varying from 8 to 32 in each ascus, in ours usually 12 to 16.

Collected in the northeastern portion of the State at Grand Portage, in the Misquah Hills, and at Tofte. On trees, especially balsams.

Elsewhere in North America in Massachusetts and Illinois. Known also in Europe.

11. *Lecanora varia* (Hoffm.) Ach. Lich. Univ. 377. 1810.

Patellaria varia Hoffm. Descr. Pl. Crypt. 1: 102. pl. 23. f. 4. 1790.

Thallus crustose and thin, thick, or even disappearing, smoothish or verrucose-urceolate, suborbicular, 15 to 60 mm. in diameter, or irregular and widely spread over the substratum, pale greenish, yellowish, or whitish; apothecia small or minute, 0.4 to 1 mm. in diameter, adnate or more or less immersed, the disk flat or convex and flesh-colored or passing into yellowish or buff, the exciple entire or crenulate, sometimes disappearing; hypothecium pale; hymenium of the same color below and

frequently brownish above; paraphyses simple or rarely branched toward the apex, there sometimes enlarged and darker; asci clavate; spores ellipsoid or oblong-ellipsoid, 10 to 14 μ long and 4 to 7 μ wide.

Generally distributed over the State. On trees and old wood and rarely on rocks.

The species is distributed throughout North America. Known also in all of the grand divisions.

11a. *Lecanora varia symmicta* Ach. Lich. Univ. 379. 1810.

Thallus thin, smooth or becoming subleprose, most commonly yellowish; apothecia becoming convex and the exciple entire or disappearing, the disk of the usual colors or blackening.

Generally distributed over the State. On old wood, especially old boards.

The plant has a general North American distribution. Known also in Europe and Asia.

11b. *Lecanora varia saepincola* (Ach.) Nyl. Not. Sällsk. Faun. Flor. Fenn. 5: 164. 1861.

Lecidea saepincola Ach. Syn. Lich. 35. 1814.

Thallus thick, more or less granulate-roughened, of same color as the last; apothecia of the usual size, the disk convex and reddish-olivaceous or black, slightly pruinose, the exciple commonly absent and the apothecia biatoroid. Apothecia frequently lighter-colored in ours.

Recorded only from the northern portion of the State, but no doubt also occurring farther south. On old wood.

Not so frequently reported as the last, but still widely distributed in North America. Known also in Europe.

12. *Lecanora polytropa* (Hoffm.) Schaer. Enum. Lich. Eur. 81. 1850.

Verrucaria polytropa Hoffm. Deutsch. Fl. 2: 196. 1795.

Thallus crustose or subsquamulose of small squamules, thicker than in the last, somewhat roughened and chinky or becoming subareolate, or rarely even heaped-granulate, the crust continuous or scattered over larger or smaller areas, or sometimes disappearing, pale sea-green varying toward yellowish; apothecia small or scarcely middle-sized, 0.5 to 1.3 mm. in diameter, adnate, the disk flat with an entire, flexuous, or subcrenulate exciple, or even becoming convex and the exciple disappearing, somewhat darker-colored than the thallus or scarcely differing; hypothecium and hymenium pale; asci clavate; paraphyses simple or rarely branched toward the very slightly enlarged and colored apex; spores ellipsoid, 10 to 13 μ long and 5 to 6 μ wide.

Easily confused with forms of *Lecanora muralis*.

Reported from several localities in the northwestern portion of the State, and no doubt to be found farther east also. On rocks.

Elsewhere in North America in the mountains of New England and California and northward to arctic America. Known also in South America, Europe, and Asia.

Lecanora varia polytropa is the synonym of the preliminary reports.

12a. *Lecanora polytropa melaena* Hedl. Bih. Svensk. Vet. Akad. Handl. 18^{m.3} 3: 38. 1892.

Thallus composed of contiguous or scattered, entire or subcrenate areoles or squamules; apothecia immersed or more or less superficial, scarcely reaching 1 mm. in diameter; the disk flat or becoming convex or even subglobular.

A single collection was made in 1903 on Mount Josephine at Grand Portage. On rocks.

Not previously reported from North America. Found in the Scandinavian Peninsula in Europe.

13. *Lecanora erysibe* (Ach.) Nyl. Not. Sällsk. Faun. Flor. Fenn. 5: 167. 1861.

Lichen erysibe Ach. Lich. Suec. 50. 1798.

Thallus crustose and somewhat thin, composed of olivaceous granules, which vary in color toward ashy or greenish, and run together to form a leprose or subareolate crust, suborbicular and 10 to 25 mm. in diameter, or more frequently irregular and more widely spread over the substratum, the areoles or granules rarely somewhat scattered; apothecia small or minute, 0.5 to 1 mm. in diameter, adnate, the disk flat or more or less convex, brown (in ours more usually black or blackish-brown), the exciple entire or crenulate, sometimes disappearing; hypothecium pale; hymenium pale beneath and brownish above; paraphyses simple or rarely branched, often slightly enlarged and darker toward the apex; asci clavate to cylindrico-clavate; spores ellipsoid, sometimes obscurely 2-celled, 10 to 14 μ long and 4 to 6 μ wide.

Collected at Minneapolis, at Mankato, and at Granite Falls. On rocks.

Elsewhere in North America in Illinois and Iowa. Known also in Europe.

14. *Lecanora pallescens* (L.) Schaer. Enum. Lich. Eur. 78. 1850.

Lichen pallescens L. Sp. Pl. 1142. 1753.

Thallus crustose, of moderate thickness and smoothish and chinky or becoming plicate, rarely rugose or even tuberculate-areolate, whitish or darker-ashy, suborbicular and of medium size, 15 to 60 mm. in diameter, or irregular and more widely spread over the substratum; apothecia middle-sized or larger, 1 to 2.5 mm. in diameter, the disk flat or more or less concave, flesh-colored varying toward whitish or yellowish, usually more or less white-pruinose, the exciple erect and entire or subentire; hypothecium pale; hymenium of the same color; paraphyses simple or rarely branched, frequently somewhat enlarged and colored toward the apex; asci clavate, cylindrico-clavate, or variously irregular, the whole wall thickened; spores ellipsoid and ovoid-ellipsoid, said to be 50 to 90 μ long and 20 to 40 μ wide, but ours sometimes only 35 μ long.

The above and the next following are scarcely well differentiated in our lichen flora and the determinations are difficult and uncertain.

Found throughout the northern portion of the State. On trees and most common on cedars in swamps.

Distributed throughout North America. Known in all of the grand divisions except Australia.

15. *Lecanora tartarea* (L.) Ach. Lich. Univ. 371. pl. 7. f. 3. 1810.

Lichen tartareus L. Sp. Pl. 1141. 1753.

Thallus crustose, thicker, and more roughened than in the last (tartareous), composed of coarser granules, which may be conglomerate and form a thick crust or more scattered when the crust is very uneven, of the same color as the last, and similarly disposed upon the substratum; apothecia middle-sized or large, 1 to 3 or in material from other States even 5 mm. in diameter, sessile or adnate, the disk yellowish and passing into brownish or brick-colored, scarcely pruinose, flat or concave, the exciple rather thick and entire or wavy; hypothecium pale; hymenium pale below and frequently more or less brownish above; paraphyses very slender, simple or rarely branched, sometimes slightly enlarged and colored toward the apex; asci clavate or more or less irregular, the walls thickened; spores ellipsoid to ovoid-ellipsoid, 30 to 65 μ long and 20 to 35 μ wide.

Collected at Ely. Some material referred to the last from the trees seems quite as much like the present, following Tuckerman's idea as to spore measurements. The collection from Ely, which undoubtedly belongs here, was made on rocks.

Generally distributed over North America, but hardly so common as the last. Known also in all of the grand divisions except Australia.

16. *Lecanora melanaspis* Ach. Lich. Univ. 427. 1810.

Parmelia melanaspis Ach. Meth. Lich. 196. 1803.

Thallus thick, crustose, and becoming verrucose-rugose or subareolate or, especially toward the margin, subfoliose, and showing linear, branched, and more or less imbricated lobes, ashy to whitish or brownish, covering considerable areas and showing a suborbicular tendency (plants at hand being 25 to 50 mm. in diameter), well developed and showing a cortical layer; apothecia small to middle-sized, 1 to 2 mm. in diameter, adnate or closely sessile, the disk flat or more or less convex, dark brown to blackish and rarely pruinose, the exciple commonly entire, but rarely becoming somewhat irregular or tending to disappear; hypothecium pale; hymenium pale beneath, usually brownish above; paraphyses simple or rarely branched, frequently enlarged, and somewhat darkened toward the apex; asci clavate; spores short-ellipsoid, 8 to 14 μ long and 5 to 9 μ wide.

The plant seems near *Lecanora rubina* in respect to thallus structure and should perhaps be placed nearer that species.

Collected at Granite Falls. On rocks.

Elsewhere in North America in Greenland, Nebraska, Kansas, South Dakota, and California. Known also in Europe.

Lecanora sp. of the fifth report of the preliminary survey.

17. *Lecanora mutabilis* (Ach.) Nyl. Mém. Soc. Sci. Nat. Cherb. 2: 324. 1854.

Urceolaria mutabilis Ach. Lich. Univ. 335. 1810.

Thallus crustose and of moderate thickness, verrucose, chinky or subareolate, dark-ashy or varying toward yellowish, usually suborbicular and middle-sized, 25 to 80 mm. in diameter; apothecia small or minute, 0.5 to 1 mm. in diameter, immersed or becoming superficial, the disk concave and urceolate, commonly black, surrounded by a proper exciple and this in turn by an inflexed thalloid one; hypothecium pale; hymenium pale throughout or darkened above; asci cylindrico-clavate to short-clavate; paraphyses slender and variously curved, simple or branched; spores roundish-ellipsoid, 30 to 52 μ long and 16 to 35 μ wide.

The plant is generally distributed over the northern portion of the State, but has been confused with *Pertusaria leioplaca*. On trees.

Elsewhere in North America in Massachusetts and New York. Known also in Europe and Africa.

Lecanora verrucosa mutabilis of the preliminary reports.

18. *Lecanora cinerea* (L.) Sommerf. Suppl. Fl. Lapp. 99. 1826.

Lichen cinereus L. Mant. Pl. 1: 132. 1767.

Thallus crustose, of moderate thickness and more or less roughened; commonly plainly areolate but sometimes smoother and chinky, or rarely verrucose rather than areolate, the areoles or verrucæ commonly about 1 mm. in diameter, ashy (cinereous) varying toward whitish or brownish, sometimes orbicular, 30 to 85 mm. in diameter, or becoming irregular and more widely spread over the substratum, in the orbicular conditions the margin sometimes delicately zonate; apothecia small to almost middle-sized, or sometimes minute, 0.5 to 1 mm. in diameter (or 1.5 according to Nylander), immersed, the disk commonly flat and black, the exciple entire and sometimes blackening; hypothecium pale; hymenium pale below and frequently brownish or olivaceous above; paraphyses simple or rather rarely branched, the apices sometimes slightly enlarged and colored; asci clavate; spores ovoid or ellipsoid, 14 to 26 μ long and 7 to 16 μ wide.

The plant is very variable, and it might perhaps conduce to clearness to follow the European lichenists in recognizing even a larger number of subspecies.

Generally distributed over the State. On rocks other than calcareous.

Known throughout North America. Found in all of the grand divisions except Australia.

18a. *Lecanora cinerea laevata* (Fr.) Tuck. Syn. N. A. Lich. 1: 198. 1882.

Parmelia cinerea laevata Fr. Lich. Eur. 145. 1831.

Thallus thinner and smooth but becoming somewhat chinky, never areolate; surface usually more or less shining; apothecia always immersed, minute and often irregular.

Throughout the northern portion of the State and as far south as Taylors Falls. On rocks other than calcareous.

Reported from North American stations as remote as Labrador, Alabama, and California, and no doubt generally distributed, though rare. Known also in Europe and Asia.

18b. *Lecanora cinerea gibbosa* (Ach.) Tuck. Syn. N. A. Lich. 1: 198. 1882.

Lichen gibbosus Ach. Lich. Suec. 30. 1798.

Thallus thick and conspicuously roughened-verrucose or areolate, on the whole darker than the last; apothecia becoming superficial and larger; spores also rather larger.

Generally distributed in the State. On the same substrata and more common than the last.

No doubt as widely distributed in North America as the species, though apparently not yet noted from the Southern States. Found also in Europe and Asia.

18c. *Lecanora cinerea microspora* Fink.

Thallus roughened and verrucose-areolate, thinner and finer than in the last, blackish-olivaceous; apothecia and spores small, the latter in ours 11 to 16 μ long and 6 to 10 μ wide.

Collected in the Leaf Hills. On granitic boulders.

Not known elsewhere in North America. Found in Europe.

Lecanora gibbosa microspora of the preliminary reports, this unpublished name having been communicated by Dr. A. Zahlbruckner.

19. *Lecanora calcarea* (L.) Nyl. Not. Sällsk. Faun. Flor. Fenn. 5: 154. 1861.

Lichen calcareus L. Sp. Pl. 1140. 1753.

Thallus crustose, scarcely so much roughened as usual forms of the last, chinky, verrucose, or areolate, sea-green, ashy or rarely white and mealy, continuous, irregular, and spread over considerable areas, or ours more commonly inconspicuous, scattered or obscured by the numerous apothecia; apothecia of same size as those of the last, commonly immersed but in ours becoming adnate in the usual form with poorly developed thallus, the disk urceolate or flat, light brown to blackish and commonly white-pruinose, the exciple entire or rugose-plicate and surrounding a thin proper exciple; hypothecium pale; hymenium pale below and more or less colored above; paraphyses simple or branched, commonly enlarged and brownish toward the apex; asci clavate or ventricose-clavate; spores 2 to 8 in each ascus, ovoid to ellipsoid, in ours 10 to 14 μ long and 4 to 6 μ wide and 8 in each ascus (said to be 16 to 30 μ long and 12 to 20 μ wide).

The plants referred here for Minnesota and Iowa may all be regarded as doubtful, the spores being small and the thallus poorly developed. Some of the forms from the calcareous rocks are the same as were referred here by Tuckerman. Others are too near the last above, and the one reported from Mankato is much like some forms referred to *Lecanora dispersa*.

Reported from various portions of the State, but the more probable forms are from regions where calcareous rocks occur. On rocks.

Throughout the northern United States and northward into British America. Known also in Europe and Africa.

19a. *Lecanora calcarea contorta* (Hoffm.) Tuck. Syn. N. A. Lich. 1: 199. 1882.

Verrucaria contorta Hoffm. Descr. Pl. Crypt. 1: 97. pl. 22. f. 1-4. 1790.

Thallus better developed, areolate and the areoles frequently more or less scattered, commonly pale greenish lead-colored; apothecia scarcely becoming adnate and the disk sometimes punctiform; often four spores in each ascus, and the spores of the larger size mentioned above.

The subspecies is well marked.

Generally distributed over the State. On various rocks, but more common on calcareous.

Elsewhere in North America in Greenland, and various portions of the United States from Alabama northward to Illinois and westward to California. Known also in all of the grand divisions except Australia.

20. *Lecanora lacustris* (With.) Nyl. Not. Sällsk. Faun. Flor. Fenn. 5: 155. 1861.

Lichen lacustris With. Arr. Brit. Pl. ed. 3. 21. 1796.

Thallus crustose and usually thin, smooth and only slightly chinky, but becoming thicker and plainly areolate, ashy or more commonly varying toward pale brick-colored or pale olivaceous, occurring in irregular patches, in the specimens at hand 15 to 80 mm. across; apothecia small or rather minute, 0.2 to 0.5 mm. in diameter, immersed and usually urceolate, in areolate thalli usually several in each areole, the disk reddish or brownish; hypothecium pale or slightly cloudy; hymenium pale below and commonly somewhat colored above; paraphyses simple or rarely branched, the apices sometimes enlarged and slightly colored; asci clavate; spores oblong-ellipsoid, 11 to 17 μ long and 4 to 6 μ wide.

Collected at Tower. On rocks along the shore of Vermillion Lake, in places often inundated.

Elsewhere in North America, in Alaska, Greenland, New England, and Alabama. Known in Europe and Asia.

21. *Lecanora subepulotica* (Nyl.) Fink.

Lecidea subepulotica Nyl. Mém. Soc. Sci. Nat. Cherb. 4: 337. 1857.

Thallus crustose and thickened, verrucose or areolate, whitish-ashy, in ours forming small thickened areas from 2 to 6 mm. in diameter, these frequently running together to form larger patches; apothecia small, 0.2 to 0.6 mm. in diameter, adnate, the disk flat, convex or more or less irregular, flesh-colored to reddish and darkening, the exciple soon disappearing, and the whole structure becoming biatoroid, the exciple when present and the whole apothecium as well tending to be irregular in form; hypothecium pale-brownish to brown; hymenium pale reddish brown; paraphyses commonly simple, very slender, sometimes slightly enlarged and brownish toward the apex; asci cylindrico-clavate; spores ovoid-ellipsoid, 10 to 16 μ long and 6 to 9 μ wide, tending to uniseriate arrangement in the asci.

Frequently regarded a subspecies of the last, but ours is quite distinct.

Collected along the northern boundary near Emo. On rocks along Rainy River.

Elsewhere in North America in Canada, Vermont, Massachusetts, and California. Known also in Europe.

HAEMATOMMA Mass. Ric. Lich. 32. f. 53-54. 1852.

The thallus is crustose and usually thin. In some of the species there is a more or less developed upper cellular cortex, while in others no other cortical structure is present than a thin layer of gelatinized and often scarcely distinct hyphæ. The algal and medullary layers are not often distinctly differentiated, while the lower cortical layer seems to be uniformly absent. Hyphal rhizoids form the attaching organs. The algal symbionts are rather large, but do not seem to differ otherwise from the

ordinary *Cystococcus*. In most of the species soredia occur scattered over the upper surface of the thallus. Shades of sea-green and yellow are the prevailing colors of the thalli.

The apothecia are of medium size or larger and are either sessile or adnate. The exciple shows much the same structure as the upper cortex and is thus scarcely so well developed as that of the *Lecanoras*. The algæ of the exciple are not numerous, and the whole structure appears to be somewhat biatoroid. Indeed, the exciple may disappear entirely, leaving the apothecium strictly biatoroid. The hypothecium is pale. The paraphyses are slender, and commonly simple, though branched forms may be looked for in all of the species. The spores are long and acicular, hyaline, variously curved, and 4 to several-celled.

The relations of the genus are not difficult to trace. As to the structure of the thallus and the apothecia the resemblance to a majority of the *Lecanoras* is apparent enough. When we turn to the spores, we note a similarity to those of the *Bacidias*. The thallus also is only a little higher in development than that of the *Bacidias*, while the poorly developed thalloid exciple points to a more or less close relationship with the same genus. On the whole, it may well be doubted whether the present genus is more closely related to *Lecanora* than to *Bacidia*.

Only a few species of the genus are known in North America, and of these only one has been noted in Minnesota.

Type species *Haematomma vulgare* Mass. loc. cit.

1. *Haematomma elatinum* (Ach.) Koerb. Syst. Lich. 153. 1855.

Lecanora elatina Ach. Lich. Univ. 387. 1810.

Thallus crustose and thin, smooth and somewhat chinky or more commonly becoming densely granulate or powdery, ashy-white or faintly yellowish, closely adnate and attached by hyphal rhizoids, in the less powdery conditions an upper pseudo-cortex distinguishable as a thin structureless and gelatinized mass or faintly showing coherent hyphæ; apothecia small to middle-sized, 0.5 to 1.5 mm. in diameter, sessile, the disk commonly flat or finally convex, and from light brownish to dark reddish brown, frequently somewhat pruinose, the thalloid exciple irregular and evanescent, leaving the apothecium strictly biatoroid; hypothecium pale; hymenium of the same color or darker above; paraphyses simple or rarely branched toward the commonly thickened and somewhat colored apex; asci clavate or cylindrico-clavate; spores fusiform-acicular, curved, 4 to 6-celled, 38 to 58 μ long and 4 to 6 μ wide.

A single collection has been made, at Tofte. On trees.

Found in New England, New York, North Carolina, and northward throughout British America. Known also in Europe and Asia. Perhaps more widely distributed, but the synonymy is uncertain.

Lecanora elatina of the preliminary reports.

Family PERTUSARIACEAE.

In the Pertusariaceae we have a family which is extremely troublesome, though composed of a single genus. We have followed Zahlbruckner in recognizing the family, but have not seen our way to follow him in separating the large-spored *Lecanoras*, *L. tartarea* and *L. pallescens*, under the generic name *Ochrolechia*, and placing them in the present family. It is true, however, that certain members of the present family tend toward the open condition of apothecium and seem very closely related to these *Lecanoras*. We have recognized this close relationship in placing the Pertusariaceae next after the Lecanoraceae.

On the other hand, the apothecia more commonly open by an apical pore, and Schneider has seen fit to place the genus *Pertusaria* with the Verrucariaceae without recognizing the family Pertusariaceae at all. And his position is not without strong

claims when we consider the close structural relationship of the apothecia of a large number of *Pertusarias* with those of the *Trypetheliums*, not represented in our flora. In placing the present family next to the *Lecanoraceae*, it is only fair to admit this other perhaps equally close relationship.

The crustose thallus, the nature of the algal symbiont, the peculiar grouping of the apothecia in verrucæ of the thallus (the grouping quite *Trypethelium*-like), and the large size of the spores all receive attention in the description of the genus.

PERTUSARIA Lam. & DC. Fl. Fr. ed. 3. 2: 319. 1805.

The thallus is strictly crustose. In one or two species, however, a poorly developed upper cellular cortex can be made out. In others there is a thin upper pseudo-cortex of interwoven hyphæ, which are frequently gelatinized into a structureless layer. The algal and medullary layers are frequently well differentiated, but in none of our species is any suggestion of a lower cortex found. Hyphal rhizoids serve as attaching organs after the manner of crustose thalli in general. The thallus varies considerably in thickness, and in at least one of our species it is mainly hypophlœodal. Sea green and ashy are the common colors. The algal symbionts are *Cystococcus*, and the algal cells are quite uniform in the different species, apparently scarcely modified by their association with the fungal symbionts.

The apothecia are small or minute, commonly globose and immersed in the elevations or verrucæ of the thallus, often a half dozen or more in a single verruca. The apothecium commonly opens by a small pore, which is not always evident except in sections cut through it. However, in some of the species the apothecia or the verrucæ become open and disk-like, or rather the globular structure becomes depressed, for the thallus which always covers the structure either remains intact or breaks up into a sorediate mass. The paraphyses are commonly more or less branched and hyaline throughout. The hypothecium and hymenium are pale, or the latter sometimes brownish above. The asci are clavate, cylindrico-clavate, or variously irregular, with rather thick walls. The spores are hyaline or pale, very large and simple, though some authors admit 2-celled forms. There are from 1 to 8 spores in each ascus, and the spore walls are quite thick.

The relationships of the genus are by no means certain. The thallus structure and the spores look toward *Lecanora* and allied genera. The very presence of what may be regarded a perithecium would seem to indicate a close relation to *Pyrenula* and *Trypethelium*. However, the so-called perithecium is here quite a different structure, and the thallus is much better developed and commonly epiphlœodal. Tuckerman gives one view of relationships clearly in his genera.^a Seven species and subspecies occur in the State. On trees and rarely on rocks.

Type species *Pertusaria communis* DC. loc. cit.

KEY TO THE SPECIES.

Thallus usually lighter-colored or zonate toward the circumference.

Thallus usually becoming rough.

Spores 130 to 250 μ long, one in each ascus..... 1. *P. velata*.

Spores 75 to 150 μ long, one or two in each ascus..... 2. *P. multipuncta*.

Thallus smooth and thin; spores as in the last above..... 2a. *P. multipuncta ophthalmiza*.

Thallus scarcely lighter-colored or zonate toward the circumference.

Apothecia 2 to several in each verruca; spores 100 to 180 μ

long, 1 or 2 in each ascus..... 3. *P. communis*.

^a Page 125.

Apothecia 1 to 5 in each verruca.

Spores 4 to 8 in each ascus..... 6. *P. leioplaca*.

Spores 1 or 2 in each ascus.

Thallus sea-green to ashy, yellowish or brownish;
apothecia-containing verrucæ somewhat raised.. 4. *P. pustulata*.

Thallus whitish; apothecia-containing verrucæ
flattish..... 5. *P. finkii*.

1. ***Pertusaria velata*** (Turn.) Nyl. Not. Sällsk. Faun. Flor. Fenn. **5**: 179. 1861.

Parmelia velata Turn. Trans. Linn. Soc. Lond. **9**: 143. *pl. 12. f. 1.* 1808.

PLATE 34, B.

Thallus rather thin and smooth or becoming thicker and plicate-rugose, chinky or somewhat irregularly roughened or verrucose, sea-green to milky-white, suborbicular, 3.5 to 10 cm. in longest dimension, the circumference commonly lighter-colored and frequently zonate, the upper pseudocortex of interwoven hyphæ and becoming a structureless mass; apothecia immersed 2 or 3 in a small to almost middle-sized verruca, this 0.4 to 1.2 mm. in diameter, depressed and disk-shaped, the disk concave and usually lighter than the thallus, and sometimes densely white-soresiate; hypothecium commonly pale; hymenium pale below and commonly brownish above; paraphyses quite commonly branched, not often enlarged or darker toward the apex; asci cylindrical or cylindrico-clavate; spores oblong-ellipsoid, 150 to 250 μ long and 40 to 80 μ wide, one in each ascus, or, according to Tuckerman, rarely two.

Found throughout the State. On trees and rarely on rocks.

Throughout eastern North America and westward to the Rocky mountains. Also in Alaska. Known in all of the grand divisions.

EXPLANATION of Plate 34.—See page 180.

2. ***Pertusaria multipuncta*** (Turn.) Nyl. Not. Sällsk. Faun. Flor. Fenn. **5**: 179. 1861.

Variolaria multipuncta Turn. Trans. Linn. Soc. Lond. **9**: 137. *pl. 10. f. 1.* 1808.

Thallus much as in the last, but on the whole inclined to be thinner and smoother, sea-green to pale ashy, more inclined to irregularity in form and either not lighter and zonate toward the circumference or indistinctly so, cortex as in the last or even less developed; apothecia-containing verrucæ also much as in the last, but not so uniformly depressed and disk-like, frequently becoming irregular and blackened, or passing into powdery-soresiate heaps, numbering 2 to 4 in each verruca; hypothecium, hymenium, and paraphyses as in the last; asci more inclined to be clavate or ventricose; spores distinctly smaller, 75 to 150 μ long and 25 to 65 μ wide, one in each ascus, or rarely two.

Throughout the northern portion of the State. On trees.

Distributed throughout North America. Found also in all the grand divisions except Africa.

2a. ***Pertusaria multipuncta ophthalmiza*** Nyl. Not. Sällsk. Faun. Flor. Fenn. **5**: 180. 1861.

Thallus thin and smooth; apothecia-bearing verrucæ uniformly disk-like and blackening above, usually scattered and each containing a single apothecium.

Distribution in the State as that of the species. On trees and old wood.

Elsewhere in North America in Newfoundland or Labrador. Known also in Europe.

Pertusaria ophthalmiza and *P. multipuncta laevigata* of the preliminary reports.

3. ***Pertusaria communis*** Lam. & DC. Fl. Fr. ed. 3. **2**: 320. 1805.

FIGURE 15.

Thallus thin and smoothish or soon becoming rougher and chinky and finally strongly rugose-verrucose and subareolate, sea-green or lighter-colored and rarely somewhat zonate at the circumference, commonly irregular and often widely spread over the substratum, the layers distinct, but the upper cortex commonly a structureless gelatinized mass; apothecia-containing verrucæ 0.5 to 2 mm. in diameter, de-

pressed-subglobose (not disk-shaped) and variously irregular, apothecia 2 to several in each verruca, and the verrucæ closed except at the sunken, commonly black but usually inconspicuous pores of the apothecia; hypothecium pale; hymenium pale below and sometimes more or less brownish above; paraphyses slender and usually

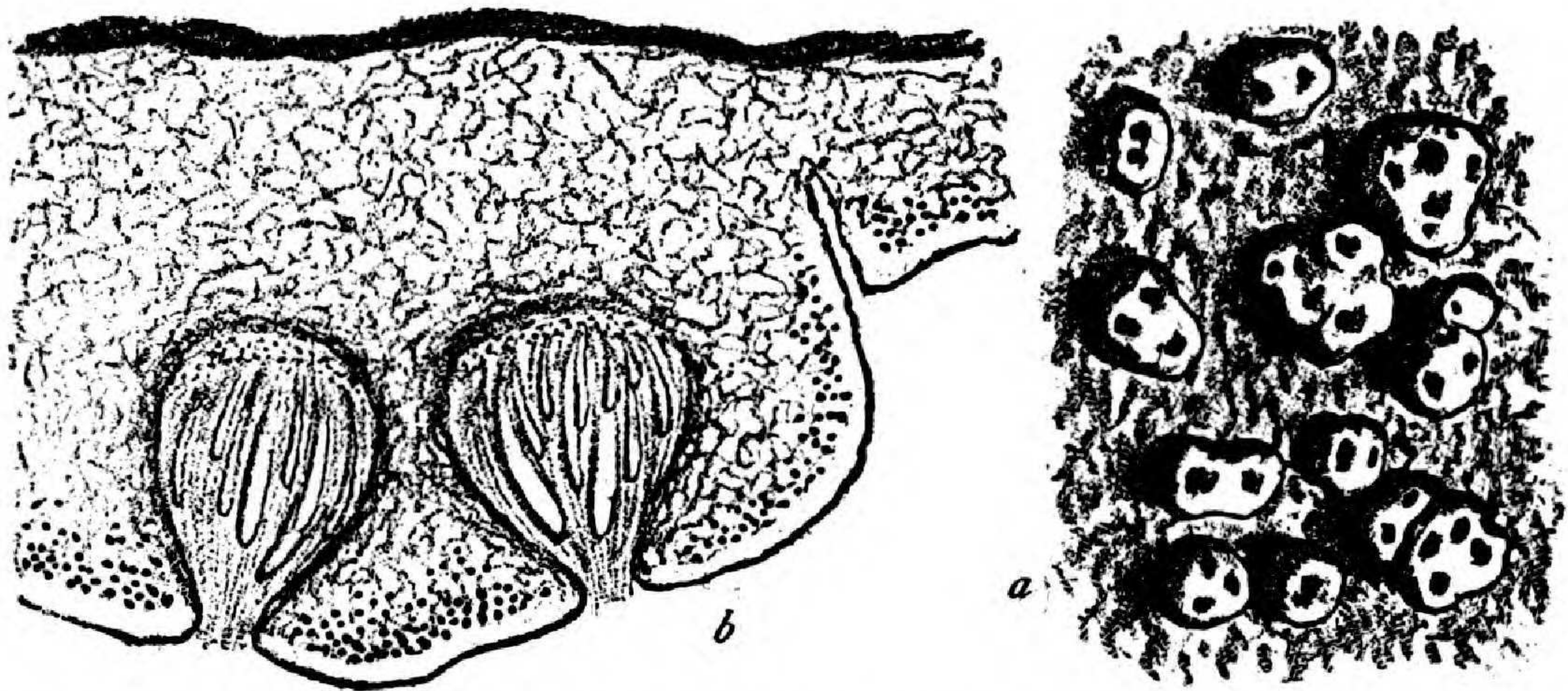


FIG. 15.—*Pertusaria communis*. *a*, Thallus with the apothecia-containing verrucæ and the ostioles; *b*, a section of a verruca, showing two of the immersed apothecia. *a*, Enlarged 3 diameters; *b*, 30 diameters. From Reinke.

more or less branched; asci cylindrical or cylindrico-clavate; spores 100 to 180 μ long and 40 to 70 μ wide, 1, 2 (or rarely 4 ?) in each ascus.

Generally distributed throughout the State. On trees and rarely on dead wood or rocks.

Found throughout North America. Known in some form in all of the grand divisions.

4. *Pertusaria pustulata* (Ach.) Nyl. Act. Soc. Linn. Bord. 21: 441. 1856.

Porina pustulata Ach. Lich. Univ. 309. 1810.

Thallus thinner and smoother than that of the last, but becoming chinky or even somewhat verrucose, sea-green varying toward ashy, yellowish or brownish, often sub-orbicular, 2.5 to 4 cm. across, or irregular and covering smaller areas of the substratum than that of the last, upper cortex as in the last and the thallus inclined to be partly hypophlœodal, or apparently more so than our other species; apothecia-containing verrucæ small, 0.4 to 1 mm. in diameter, only slightly raised; difform or becoming irregularly-hemispherical; apothecia 1 to 4 or 5 in each verruca, the black pores sometimes becoming conspicuous and disk-like; hypothecium pale; hymenium pale below and commonly brownish above; paraphyses slender and commonly branched, somewhat enlarged toward the apex; asci as in the last; spores oblong-ellipsoid, 50 to 135 μ long and 25 to 56 μ wide, 2 in each ascus.

Well distributed over the State. On trees.

Generally distributed over North America, but apparently not common toward the Pacific Coast. Known in all of the grand divisions.

5. *Pertusaria finkii* Zahlbr. in Fink, Minn. Bot. Stud. 2: 696. 1901.

Thallus thin and smooth or becoming chinky and somewhat verrucose, whitish in color, commonly occurring in small and somewhat irregular patches, scarcely more than 1.5 to 4 cm. across, without definite upper cortex; apothecia-containing verrucæ small to middle-sized, 0.5 to 2 mm. in diameter, flattened and rather inconspicuous; apothecia 1 to about 5 in each verruca, the pores brown or blackish, or the apothecium becoming open and disk-like and of the same color; hypothecium pale; hymenium pale below and brownish above; paraphyses slender and somewhat coherent, simple or branched, rarely enlarged or darker toward the apex; asci clavate or cylindrico-clavate; spores oblong-ellipsoid, sometimes constricted along the sides, 70 to 140 μ long, and 28 to 53 μ wide, 2, or rarely 1, in each ascus.

Found in several localities in the northern portion of the State. On hard wood trees, especially oaks and cottonwood, and to be looked for wherever these trees occur in northern Minnesota. Besides the localities noted in the sixth preliminary report, the plant was seen in 1902 at several points on the north shore of Lake Superior from Grand Marais to Duluth.

A North American lichen not known elsewhere.

6. *Pertusaria leioplaca* (Ach.) Schaer. Lich. Helv. Spic. 2: 66. 1823.

Porina leioplaca Ach. Lich. Univ. 309. pl. 7. f. 2. 1810.

Thallus thin and smooth or becoming somewhat chinky and verrucose, sea-green to pale yellowish, disposed upon the substratum much as in the last, but the patches on the whole smaller, also inclined to hypophlœodal conditions, some of ours showing a poorly developed upper cellular cortex (this no doubt sometimes existing in specimens of other species not thus credited, the plants varying somewhat in this respect even within a species); apothecia-containing verrucæ small to middle-sized 0.6 to 2 mm. in diameter, hemispherical and somewhat irregular, scattered or crowded; apothecia one or few in each verruca, the pore rarely depressed and sometimes becoming black and conspicuous, or the whole verruca rarely becoming depressed and disk-like; hypothecium pale; hymenium pale beneath and commonly brownish above; paraphyses commonly branched and rarely somewhat enlarged toward the apex; asci cylindric-clavate; spores oblong-ellipsoid, 4 to 8 in each ascus and varying in size according to number, hence 40 to 180 μ long and 20 to 50 μ wide.

Not often collected, but no doubt generally distributed over the State. On trees.

Found throughout North America. Known in all of the grand divisions.

FAMILY PARMELIACEAE.

This family is represented in our flora by 6 genera, of which *Parmelia* is the largest, having more than 20 forms in the State. However, the whole family with its 6 genera has not as many species in our flora as the *Cladoniaceae* with their single genus. The family is most closely related to the *Lecanoraceae* below and to the *Physciaceae* and the *Teloschistaceae* above. The relationship with the *Lecanoraceae* was stated in the discussion of that family. Of the two families next preceding this it is not so easy to decide which is more closely related to it. If we consider superficial resemblance in color and form of thallus, doubtless the genus *Physcia* of the *Physciaceae* would stand nearest, but the spore characters should doubtless have greater weight. As regards the latter, the 2-celled spores of *Ramalina* look somewhat toward the similar but brown spores of *Physcia*, while colored spores are also found in the present family in *Alectoria*. Turning to the *Teloschistaceae*, however, every condition from the typical polar 2-celled spore to the simple spore is found in both of the two genera of the family, the nonpolar 2-celled spores being quite like those of *Ramalina*, and the much rarer simple ones not very different from those of the *Parmelias*. Thus we may bridge over an apparent difficulty in the polar spores, so that the *Teloschistaceae* appear after all closer to the *Parmeliaceae* than do the *Physciaceae*, and no doubt the *Physciaceae* should stand highest among the *Discocarpaceae*.

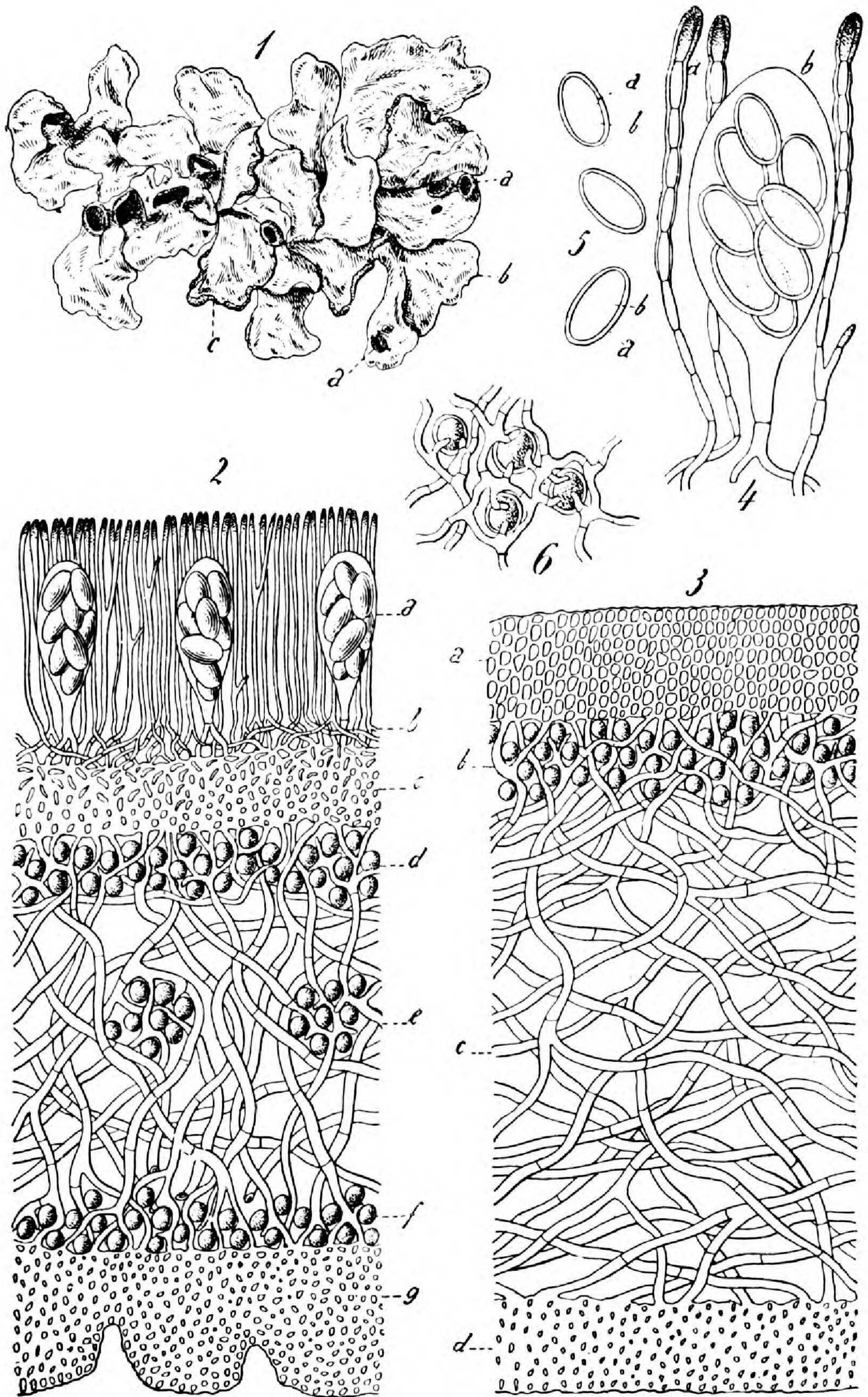
The thallus is either foliose with dorsiventral symmetry or fruticose with more or less well defined radial symmetry. A cellular cortex or a pseudocortex of hyphæ is always present, the former in the foliose species and the latter usually in the more or less plainly fruticose ones. The algal symbiont is *Cystococcus*.

The apothecia vary in position from subpedicellate to immersed. The spores are simple or 2-celled and almost always colorless, those of some *Alectorias* being sometimes brownish.

PARMELIA Ach. Meth. Lich. xxxiii, 154. pl. 4. f. 3-6. 1803.

PLATE 35.

The thallus is foliose or rarely somewhat fruticose, the former in all of ours. In some species it is freely dichotomously lobed, while in others it is nearly entire, the margin



PARMELIA PERLATA (L.) ACH.

merely being more or less indented. Soredia and isidioid growths are quite common on the upper surface of the thallus, largely replacing apothecia as reproductive bodies. The upper and the lower cortical layers are cellular and well developed. The algal layer is in the usual position for dorsiventral thalli, viz, just below the upper cortical layer. The medullary tissue consists of the usual loosely interwoven hyphæ, and in some species the lower portion of this tissue is very loosely interwoven and contains large air spaces. Rhizoids are usually present on the lower surface of the thallus, and cilia frequently occur along the margins or on the upper surface. Spermagones are conspicuous.

The apothecia are sessile or subpedicellate on the upper surface of the thallus, the thalloid margin is usually entire or more or less crenate, the disk is usually brown and often deeply concave, the hypothecium is pale or slightly colored and frequently shows two distinct layers, the hymenium is pale or yellowish or brownish tinged. The paraphyses are usually simple and slender, and the spores are simple, hyaline, and much alike in form and size in the different species. Apothecia are very rare in more than half of our species.

In appearance and structure of the thallus the genus seems near to *Physcia*, but when we take into consideration the spore characters, doubtless the relationship with *Cetraria* is closer. The relation between the present genus and the higher simple-spored *Lecanoras* with foliose thallus is also close. *Parmelia* seems to stand between *Lecanora* and *Cetraria*.

The genus is represented in Minnesota by no less than 22 forms and is the largest of our foliose genera.

Parmelias occur on trees, old wood, rocks, and rarely on the earth or over mosses.

Type species *Parmelia elacista* Ach. op. cit. 159. pl. 4. f. 4. But this is a *Lecanora* (*L. elacista*), and the generic name *Parmelia* would take precedence over *Lecanora*. See note under *Gyalecta*.

EXPLANATION OF PLATE 35.—Fig. 1, *a*, apothecia; *b*, the thallus. Fig. 2, a section of an apothecium and the thallus below; *a*, the hymenium; *b* and *c*, the hypothecium; *d*, the algal layer; *e*, the medullary layer; *f*, a lower algal layer; *g*, the lower cortex. Fig. 3, a section of the thallus; *a*, the upper cortex; *b*, the algal layer; *c*, the medullary layer; *d*, the lower cortex. Fig. 4, paraphyses and an ascus. Fig. 5, free simple spores. Fig. 6, algal cells, haustoria, and hyphæ. Fig. 1, natural size; figs. 2 and 3, enlarged 400 diameters; figs. 4, 5, and 6, enlarged 650 diameters. From Schneider.

KEY TO THE SPECIES.

Thallus never sea-green.

Thallus straw-colored.

Thallus large, with short, wide lobes; commonly on wood..... 13. *P. caperata*.

Thallus smaller, or with longer, narrower lobes; commonly on rocks.

Thallus medium-sized or larger, with long, narrow lobes..... 14. *P. conspersa*.

Thallus quite small, the center often falling away. 15. *P. centrifuga*.

Thallus olivaceous.

Apothecia absent in ours; a larger plant than the next, less closely adnate and isidioid or sorediate..... 12. *P. conspurcata*.

Apothecia present, at least usually.

Thallus lobes and the exciple densely covered with minute verrucæ..... 11a. *P. olivacea aspidota*.

Thallus lobes and exciple not verruca-bearing.

Thallus lobes much crowded and imbricated; on rocks..... 11b. *P. olivacea prolixa*.

Thallus lobes not much crowded and imbricated; on wood..... 11. *P. olivacea*.

Thallus usually sea-green.

Thallus showing open spaces within (inflated).

Thallus punctured with small holes..... 9. *P. pertusa*.

Thallus not punctured with holes..... 8. *P. physodes*.

Thallus not inflated.

Thallus frequently more or less isidioid above.

Thallus densely beset above with granules or isidioid branchlets.

Thallus margin ciliate; dark and rhizoid-bearing below..... 4. *P. crinita*.

Thallus margin not ciliate; light-colored and rhizoid-bearing below..... 6a. *P. borneri* *reducta*.

Thallus not densely beset above with granules or isidioid branchlets.

Thallus margin ciliate; dark and densely rhizoid-bearing below..... 1a. *P. perlata ciliata*.

Thallus margin not ciliate.

Thallus sorediate above, dark and rhizoid-bearing below..... 7a. *P. saxatilis sulcata*.

Thallus not sorediate above, dark and rhizoid-bearing below.

Thallus lobes long, not densely crowded and imbricated..... 7. *P. saxatilis*.

Thallus lobes short, densely crowded and imbricated..... 7b. *P. saxatilis pan-niformis*.

Thallus without isidioid branchlets above.

Thallus rather small, scarcely surpassing 90 mm. in diameter; below black and densely rhizoid-bearing..... 5. *P. tiliacea*.

Thallus larger, often reaching 15 cm. in diameter.

Thallus margin often ciliate.

Thallus dark below, where rhizoid-bearing; apothecia perforate.

Thallus quite rigid, rugose toward the center..... 2. *P. perforata*.

Thallus less often rugose, thinner margin; more often sorediate..... 3. *P. cetrata*.

Thallus light-colored below; apothecia perforate..... 2a. *P. perforata hypotropa*.

Thallus margin not ciliate.

Thallus light-colored below, where rhizoid-bearing..... 6. *P. borneri*.

Thallus dark below.

Thallus sorediate above, rather small; sparingly rhizoid-bearing below.... 10. *P. aleurites*.

Thallus not sorediate above, except sometimes at the margin, much larger; strongly rhizoid-bearing below..... 1. *P. perlata*.

1. *Parmelia perlata* (L.) Ach. Meth. 216. 1803.

PLATE 35.

Lichen perlatus L. Syst. Nat. ed. 12. 712. 1767.

Thallus prostrate, the margins usually slightly ascendant, commonly orbicular in outline, the somewhat imbricated lobes rather large, with rounded undulate margins, these without cilia but frequently clothed with white soredia; pale or darker sea-green above, below black with brown margins and clothed here and there with black rhizoids; good-sized or sometimes very large, commonly 7.5 to 20 cm. in diameter, in extreme examples reaching 45 cm.; apothecia of middle size, 4 to 8 mm. in diameter, with chestnut disk and entire margin; spores ellipsoid, 10 to 17 μ long and 6 to 10 μ wide.

Ours sterile and apothecia not seen. The above apothecial and spore characters are taken from Nylander.

Found only in the northern portion of the State and rather infrequent. On rocks or more rarely on trees.

Distributed throughout the northern United States, Alaska, and British America, especially in mountains. Known in all the grand divisions, but usually not extending into extreme arctic regions.

1a. *Parmelia perlata ciliata* (Lam. & DC.) Schaer. Enum. Lich. Eur. 34. 1850.*Lobaria perlata ciliata* Lam. & DC. Fl. Fr. ed. 3. 2: 403. 1805.

Thallus lobes as above or frequently more dissected, their margins and sometimes the upper surface black-ciliate and the surface frequently bearing soredia and isidioid growths.

Ours more densely rhizoid-bearing below than the type. Sterile.

A rare plant in the State, collected on Carlton Peak and at Rainy Lake City. On trees and mossy rocks. Also no. 362 from Gunflint referred to *Parmelia crinita* belongs here.

Little is known of the plant in America, but Nylander reports it from all of the grand divisions except Asia.

2. *Parmelia perforata* (Wulf.) Ach. Meth. Lich. 217. 1803.*Lichen perforatus* Wulf. in Jacq. Coll. Bot. 1: 116. 1786.

Thallus prostrate with ascendant margins, commonly orbicular in outline, the lobes rather large and somewhat imbricate, with rounded margins usually more or less crenate or irregular and ciliate, the upper surface sea-green or whitish and frequently rugose toward the center, beneath black or brownish black and usually brown toward the margin, bearing strong black rhizoids over the greater portion of the lower surface, usually large, 7.5 to 15 cm. in diameter; apothecia rather large, 2 to 12 mm. in diameter, subpedicellate, with chestnut disk, this deeply concave or even cyathiform, commonly perforate at the center, the margin entire or crenate; hypothecium pale or slightly yellowish; hymenium colorless below and brownish just below the epithecium; paraphyses commonly simple and slender, the apex usually brownish and thickened; asci clavate; spores oblong-ellipsoid, 9 to 14 μ long and 6 to 7.5 μ wide.

Collected at Taylors Falls on rocks and at Mankato on trees. A rare plant in Minnesota, but doubtless distributed quite generally over the southern half of the State. The doubtful plant recorded from Carlton Peak belongs to the subspecies above, though, as Tuckerman remarks, it is "quite as much at home in the present species."

Widely distributed in North America and known in all the grand divisions except Asia.

2a. *Parmelia perforata hypotropa* Nyl. Syn. Meth. Lich. 1: 378. 1858.

Thallus rather light sea-green above and pale or slightly brownish below, where it is clothed with white or slightly colored rhizoids, the upper surface and the margins somewhat sorediate, the margins not ciliate.

Sterile and on the whole appearing more like *Parmelia perlata* except for the pale color.

Once collected, at Grand Portage on rocks.

A strictly North American plant, reported from widely separate areas in the United States and Mexico.

3. *Parmelia cetrata* Ach. Syn. Meth. Lich. 198. 1814.

Thallus usually large, 8.5 to 16.5 cm. in diameter, prostrate, the lobes frequently crowded and much more ascendant than in the last, the margins of the lobes sometimes densely sorediate and, in ours at least, sometimes quite ciliate, rather thinner than the last and less inclined to become rugose toward the center, the upper surface light or darker sea-green, beneath black but usually brown toward the margin, clothed with rhizoids rather smaller than those of the last.

Ours sterile—fructed specimens not seen; apothecia and spores said to be like those of the last, of which Nylander regarded it as a subspecies.

A rare lichen in Minnesota. Two specimens were collected on rocks at Granite Falls. No. 513 from that place is undoubtedly this species, having the more ascendant, densely crowded, and strongly sorediate lobes. No. 514 is an intermediate form, quite as near the last species above.

Tuckerman gives the species a wide North American distribution, and it seems to be a strictly American lichen. Known in South America also.

4. *Parmelia crinita* Ach. Syn. Meth. Lich. 196. 1814.

Thallus usually large, 7.5 to 16 cm. in diameter, prostrate with slightly ascendant margin, densely beset with granules or isidioid branchlets, light or darker sea-green, the lobes rather large, rounded and frequently imbricate, their margins rather inconspicuously ciliate and entire, somewhat irregular or crenate, beneath black or rarely partly brown, usually of the latter color toward the margins, the lower surface clothed with rhizoids like those of the last species; apothecia subpedicellate, rare, those examined small (3 to 5 mm.), though Nylander gives 4 to 14 mm. in diameter, deeply concave, the disk chestnut, the margin crenate, irregular or isidioid, frequently ciliate; hypothecium pale or yellowish; hymenium pale below and brownish above; paraphyses simple, slender, the tips pale or yellowish and usually thickened; asci broadly clavate; spores simple, ellipsoid, their walls thick, 17 to 22 μ long and 9 to 15 μ wide.

Generally distributed over the State, but by no means common. On trees and rarely on rocks.

Distributed throughout the United States and Canada. Also known in South America, Europe, and Africa.

5. *Parmelia tiliacea* (Hoffm.) Ach. Meth. Lich. 215. 1803.

PLATE 36, A.

Lichen tiliaceus Hoffm. Enum. Lich. Icon. 26. pl. 16. f. 2. 1784.

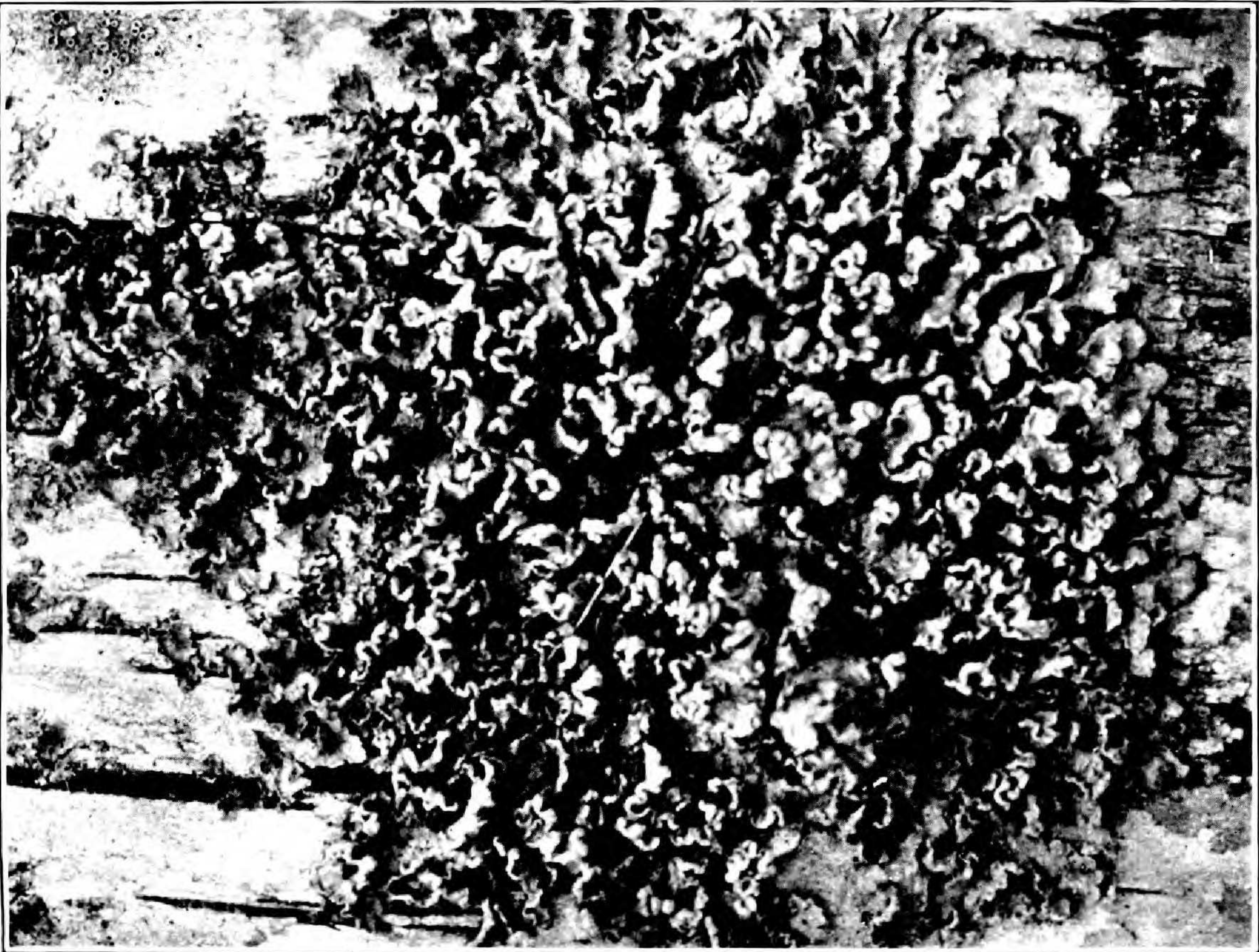
Thallus closely adnate, suborbicular in outline, rather small, 30 to 90 mm. in diameter, sea-green, the upper surface commonly rugose, especially toward the center, the lobes rather short and rounded, with crenate or irregularly divided margins or rarely elongated and subdichotomously divided, beneath black and densely covered with black rhizoids; apothecia sessile or subpedicellate, frequent and of medium size, 3 to 12 mm. in diameter, deeply concave or rarely nearly flat, the disk chestnut, the margin crenulate to crenate or rarely entire; hypothecium pale; hymenium pale or very slightly colored; paraphyses simple or rarely branched, slender, the apex pale or brownish and thickened; asci clavate; spores short-ellipsoid, 5 to 11 μ long and 5 to 7 μ wide.

Generally distributed over the State, but rare in the northeastern portion. On trees, old wood, and rocks.

A. *PARMELIA TILIACEA* (HOFFM.) ACH.



B. *CETRARIA JUNIPERINA PINASTRI* (SCOP.) ACH.





PARMELIA SAXATILIS (L.) ACH. AND P. PHYSODES (L.) ACH.

Common throughout the United States, Alaska, and British America. Distributed in all of the grand divisions.

EXPLANATION OF PLATE 36.—A, Plant of *Parmelia tiliacea* on a tree trunk, showing the closely attached foliose thallus and the sessile apothecia. B, Plant of *Cetraria juniperina pinastri* on birch bark, showing the crisped ascendant thallus lobes. A enlarged $1\frac{1}{2}$ diameters; B, $1\frac{3}{4}$ diameters.

6. *Parmelia borreri* Turn. Trans. Linn. Soc. Lond. **9**: 148. *pl. 13. f. 2.* 1808.

Thallus rather closely adnate with a sometimes free and slightly raised margin, rather large, 6 to 14.5 cm. in diameter, the upper surface sea-green or varying toward ashy or brownish, commonly rugose, rarely sorediate (more commonly so in European specimens), the margins rarely white-powdery, the lobes rather wider and shorter than in the next and usually cut crenate; lower surface ashy to pale brownish with white or darkening rhizoids; apothecia middle-sized to large, 3 to 14 mm. in diameter, loosely sessile, the disk chestnut and the margin entire, crenulate, or irregular, usually deeply concave or the smaller ones even cyathiform; hypothecium pale or brownish; hymenium pale or yellowish below and brownish above; paraphyses rather indistinct, but simple and slender, with tips usually brownish and thickened; asci clavate; spores ellipsoid, 10 to 16 μ long and 6 to 8.5 μ wide.

Widely distributed in the State, but scarcely common. Represented in the northeastern portion by the subspecies below. On trees and rarely on rocks.

Seems to be widely distributed in North America, though Tuckerman thought the first subspecies much more common and did not differentiate clearly as to distribution. Known in all the grand divisions except Australia.

6a. *Parmelia borreri rudecta* (Ach.) Tuck. Syn. Lich. N. E. 26. 1848.

Parmelia rudecta Ach. Syn. Meth. Lich. 197. 1814.

Thallus covered with isidioid branchlets or rarely mere granules, on the whole rather lighter-colored than the above, rarely fruited, and when so the apothecia small, those seen not exceeding 3 or 4 mm. in diameter.

Distributed throughout the State, but not more common than the species. On trees and rarely on rocks; most common on cedars in swamps in the northern portion of the State.

Distributed throughout North America and found also in Australia.

7. *Parmelia saxatilis* (L.) Ach. Meth. Lich. 204. 1803.

PLATE 37.

Lichen saxatilis L. Sp. Pl. 1142. 1753.

Thallus rather less closely adnate than the last and smooth or obscurely rugose, becoming rimose, often bearing isidioid granules or branchlets, sea-green or ashy, the lobes commonly long and narrow and sinuate or subdichotomously branched, somewhat imbricate, rather smaller than the last, 6 to 13.5 cm. in diameter (but reaching 17.5 cm. in rare instances), beneath black, or brownish toward the margins, and clothed with black rhizoids; apothecia rarely present, middle-sized to large, 3 to 12 mm. in diameter, sessile or subsessile, the disk chestnut, the margin entire, crenulate or irregular, concave or the smaller ones cyathiform; hypothecium and hymenium pale or yellowish; paraphyses commonly simple and slender, the apices usually brownish and thickened; asci clavate; spores ellipsoid, 12 to 16 μ long and 8 to 10 μ wide.

Distributed throughout the State, but rarely fruited. On trees, old wood, and rocks. Best developed in northern Minnesota, where the plant is oftener found fruited.

Common in northern United States and northward, but rare southward. Known in all of the grand divisions.

EXPLANATION OF PLATE 37.—*Parmelia saxatilis* and *P. physodes* taking possession of an old balsam fir. At Grand Marais. About one-twelfth natural size.

7a. *Parmelia saxatilis sulcata* (Tayl.) Nyl. Syn. Lich. 1: 389. 1858.

Parmelia sulcata Tayl. in Mack. Fl. Hibern. 2: 145. 1856.

Thallus usually wider lobed and paler and bearing rounded, oblong, or irregular soredia; apothecia seen smaller and spores also rather smaller.

Widely distributed in the State, but rare. On trees and rarely on rocks.

As widely distributed as the species in North America. Also common in northern Europe and Asia.

7b. *Parmelia saxatilis panniformis* (Ach.) Schaer. Lich. Helv. Spic. 10: 457. 1839.

Parmelia omphalodes panniformis Ach. Meth. Lich. 204. 1803.

Tuckerman says "lobes short, densely crowded, and imbricated." Ours is small, but the lobes are not shorter in proportion to size, nor are they more imbricate than ordinarily. The plant is more closely adnate than usual and well supplied with isidioid granules or branchlets. The few apothecia were small and unfortunately yielded no spores.

Collected twice in southwestern Minnesota and several times along the northern boundary. On rocks.

Elsewhere in America known in the arctic region and in the White Mountains (New Hampshire). Also in Europe.

8. *Parmelia physodes* (L.) Ach. Meth. Lich. 250. 1803.

PLATE 37.

Lichen physodes L. Sp. Pl. 1194. 1753.

Thallus of medium size, 5.5 to 10 cm. in diameter, rather loosely attached to the substratum, showing open spaces between the lower cortex and the medullary layer (inflated), usually quite smooth, sea-green or whitish, the lobes long, narrow, sinuous or dichotomously branched, somewhat imbricate with the margins frequently somewhat ascendant; beneath black or brownish black, brown or white-sorediate toward the margins, rugose and without rhizoids; apothecia rather rare, middle-sized to large, 3 to 14 mm. in diameter (or reaching 18 or 20 mm. in material from Australia), inflated-subpedicellate, the disk chestnut or lighter, the margin entire or somewhat irregular, commonly more or less concave; hypothecium pale or brownish; hymenium pale or brownish; paraphyses plainly jointed, simple or rarely branched toward the sometimes thickened and colored apex; asci broadly-clavate; spores subspherical or short-ellipsoid, 4 to 8 μ long and 4 to 6 μ wide.

Common on trees in the northern portion of the State. Rarely on rocks also. Ours sterile and the microscopic characters taken from other material.

Widely distributed in North America and common to all of the grand divisions.

EXPLANATION OF PLATE 37.—See page 195.

9. *Parmelia pertusa* (Schrank.) Schaer. Lich. Helv. Spic. 10: 457. 1839.

PLATE 38.

Lichen pertusus Schrank, Baier. Fl. 2: 519. 1789.

Thallus closely adnate, medium sized or larger, 6 to 15 cm. in diameter, showing open spaces between the lower cortex and the medullary layer (inflated), the surface shining and sea green or whitish, bearing scattered round white soredia and perforated sparingly by round or oblong holes (pertuse), the lobes crowded, imbricate, and freely branching, their margins scarcely ever ascendant; beneath black or brownish toward the margins, rugose and without rhizoids; apothecia very rare, small, the disk chestnut, the margin entire; spores 2 or 4 in each ascus, ellipsoid, 45 to 60 μ long and 22 to 28 μ wide.

Ours sterile and the apothecial and spore characters taken from Tuckerman.

Collected at Grand Marais (Hibbard photograph no. 5240). On cedars. Not known elsewhere in the State, and not previously reported.



PARMELIA PERTUSA (SCHRANK.) SCHAER.

According to Tuckerman confined for the most part to mountains and only reported by him in the mountains of New England. Has been reported from Ohio more recently and also from Alaska. Known in all of the grand divisions except Africa.

EXPLANATION OF PLATE 38.—Plant on a tree trunk, showing the pertuse foliose thallus. Natural size.

10. *Parmelia aleurites* Ach. Meth. Lich. 208. 1803.

Lichen aleurites Ach. Lich. Suec. 117. 1798.

Thallus rather small, 35 to 85 mm. in diameter or variously broken and spread over larger areas of the substratum, whitish or light sea-green, closely adnate, rugose and more or less sorediate, dark-colored and sparingly fibrillose below, the margin sometimes raised or ascending; apothecia chestnut-brown or chestnut-reddish, 1 to 3 mm. in diameter; spores oblong or oblong-fusiform, often curved, 11 to 12 μ long and 3 to 4 μ wide.

Ours sterile, the spore and apothecial characters taken from Nylander.

This is evidently the plant which Tuckerman did not distinguish from *Parmelia ambigua albescens* Wahl., but which Nylander recognized.^a Strangely enough *Cetraria aleurites* (Ach.) Th. Fr.^b can also be traced back to *Lichen aleurites* Ach. That two distinct plants are based on this plant of Acharius may be seen plainly by comparing *Cetraria aleurites* of Tuck.^c with *Parmelia aleurites* of Nylander's work cited above.

On trees at Minneapolis and on rocks at New Ulm.

Elsewhere in North America from Greenland. Known also in Europe.

11. *Parmelia olivacea* (L.) Ach. Meth. Lich. 213. 1803.

Lichen olivaceus L. Sp. Pl. 1143. 1753.

Thallus small or medium-sized, 20 to 80 mm. in diameter, closely adnate, the upper surface usually somewhat rugose and frequently bearing isidioid growths, pale or darker olivaceous, the lobes more or less radiate, frequently somewhat imbricate, more or less branched, their margins sinuate or obscurely crenate; beneath of the same color or more commonly black, bearing scattered brown or black rhizoids; apothecia small or middle-sized, 2 to 6 mm. in diameter, sessile or rarely subpedicellate, the disk chestnut or darker, the margin entire or crenulate, concave or rarely plane; hypothecium pale; hymenium pale or brownish, especially above; paraphyses simple and slender, the apex usually brownish and somewhat thickened; asci clavate; spores ellipsoid, 11 to 16 μ long and 7 to 9 μ wide.

Distributed throughout the State and common in the northern portion. On trees and old wood.

Common in the Northern States and northward; occurring farther south, but there confined mostly to mountains. Common in northern Europe and Asia and also found in northern Africa.

11a. *Parmelia olivacea aspidota* Ach. Meth. Lich. 214. 1803.

Thallus, and apothecia externally, thickly covered with minute verrucæ of the same color; spores smaller, 7 to 9 μ long and 5 to 6 μ wide; paraphyses more distinct in the material examined. Otherwise the same microscopically.

Collected in the Leaf Hills near Vining. On trees. Doubtless occurs in other parts of the State.

North American distribution about the same as that of the species. Also occurs with the species in Europe.

^a Cf. Nyl. Not. Sällsk. Faun. Flor. Fenn. 5: 105. 1861.

^b Lich. Scand. 1: 109. 1871.

^c Syn. N. A. Lich. 1: 32. 1882.

11b. *Parmelia olivacea proluxa* Ach. Meth. Lich. 214. 1803.

Thallus a dark olivaceous brown, on the whole rather better developed than that of the species, the lobes perhaps narrower, closely crowded and much imbricated, giving a rough surface above; spores smaller, 8 to 11 μ long and 5 to 6 μ wide. Ours scarcely shows as narrow lobes as we should expect from Tuckerman's brief statement, but agrees well with herbarium specimens from Europe.

Confined for the most part to the northern part of the State, though the plants from Granite Falls and New Ulm referred to *Pannaria olivacea pannariformis* Nyl.^a seem rather to belong here. On rocks.

Occurs in the mountains, both eastern and western, and descends to the north. Also found in northern Europe and Asia.

12. *Parmelia conspurcata* (Schaer.) Wainio, Medd. Soc. Faun. Flor. Fenn. 14: 22. 1888.

Parmelia olivacea corticola conspurcata Schaer. Lich. Helv. Spic. 10: 466. 1840.

Thallus larger than in the last species (3 to 10 cm. in diameter), less closely adnate, the upper surface olivaceous, more or less rugose, usually somewhat covered with commonly whitening isidioid growths or with soredia of the same color, the lobes wider and less elongated, with sinuous or crenate somewhat ascendant, rarely white-powdery margins, beneath black or brownish black, brown toward the margin, and bearing rhizoids of the same colors; apothecia not seen.

Frequent in the northern portion of the State. On trees and rarely on rocks. Number 131 from Minneapolis and number 60 from Taylors Falls, both referred to *Parmelia olivacea*, also belong here. The writer has collected the same at Concord, Massachusetts, and has a specimen from Fayette, Iowa, which seems to be the same. Nothing further is known of its North American distribution. Evidently not the same as *Parmelia olivacea sorediata* (Ach.) Nyl.,^b which is recorded in Tuckerman's Synopsis. The species is well known in Europe.

13. *Parmelia caperata* (L.) Ach. Meth. Lich. 216. 1803.

Lichen caperatus L. Sp. Pl. 1147. 1753.

Thallus medium-sized or large, 5 to 22.5 cm. in diameter, prostrate with margins frequently somewhat ascendant, the central portions most frequently quite entire and the marginal portions only shortly lobed, or the central portions as well composed of somewhat imbricated lobes, the upper surface undulate, commonly somewhat rugose, and usually isidioid or sorediate, the margins of the lobes incised, crenate, or subentire; straw-colored varying to yellowish or whitish, beneath black with rather scattered rhizoids of the same color, the margins, however, brown and the rhizoids there frequently light-colored; apothecia rare, sessile, middle-sized, 3 to 12 mm. in diameter, the disk chestnut, concave, the margin crenulate or subentire and frequently sorediate or isidioid; hypothecium pale or yellowish; hymenium pale or yellowish below and usually brownish above; paraphyses commonly simple, distinct, the tips slightly enlarged and sometimes brownish; asci clavate; spores ellipsoid, 15 to 20 μ long and 7 to 10 μ wide.

Occurs in all parts of the State, sterile except in the northern portion, where the plant is occasionally fruited. On trees, old wood, and stones.

Distributed throughout North America. Common to all of the grand divisions.

14. *Parmelia conspersa* (Ehrh.) Ach. Meth. Lich. 205. 1803.

Lichen conspersus Ehrh.; Ach. Lich. Suec. 118. 1798.

Thallus prostrate, medium-sized or larger, 5 to 15 cm. in diameter, the upper surface smooth or subrugose, the lobes long and rather narrow, crowded and imbricate, with sinuate or crenate margins, the upper surface often sorediate or isidioid toward the center, straw-colored, usually varying toward greenish or yellowish, the

^a Lich. Scand. 102. 1861.

^b Not. Sällsk. Faun. Flor. Fenn. 5: 102. 1861.

lobes frequently closely imbricated toward the center and forming a continuous crust; beneath varying from pale brownish to black and when black having brown margins; rhizoids usually present and of the same color as the lower surface; apothecia common, sessile, middle-sized, 3 to 11 mm. in diameter, the disk chestnut, concave, the margin crenulate or subentire; hypothecium pale or slightly colored; hymenium pale below and pale or brownish above; paraphyses commonly simple, somewhat thickened, and frequently brownish toward the apex; asci clavate; spores ellipsoid, 8 to 11 μ long and 4.5 to 7 μ wide.

Occurs in all portions of the State. On igneous or metamorphic rocks, and rarely on wood.

Common throughout the northern States, Alaska, and British America and farther south in mountains. Distributed in all of the grand divisions.

15. *Parmelia centrifuga* (L.) Ach. Meth. Lich. 206. 1803.

Lichen centrifugus L. Sp. Pl. 1142. 1753.

Thallus in ours rather small, 3 to 6.5 cm. in diameter, but in European specimens reaching 10 cm., prostrate, composed of narrow, elongated, convex, crowded, and imbricated, centrally more or less rugose-plicate lobes, the central crust thus formed frequently falling away and leaving only the concentrically arranged periphery, straw-colored varying from greenish to yellowish; margins of the lobes sinuous, crenate, or incised; under surface whitish with darker rhizoids; apothecia small, in American and European specimens seen 2 to 3 mm. in diameter, said, however, to be middle-sized, sessile, the disk chestnut, concave, the margin subcrenulate; hypothecium pale or yellowish; hymenium pale below and pale or brownish above; paraphyses quite distinct, plainly jointed, commonly simple, somewhat thickened at the brownish apex; asci clavate; spores ellipsoid, 7 to 10 μ long and 4.5 to 5.5 μ wide.

Ours sterile and the apothecial and spore characters taken from other material.

Once collected on rocks in the Misquah Hills.

Commonly confined to arctic or subarctic regions or to mountains, but found by Agassiz on the north shore of Lake Superior. In northern Europe and Asia as well as in North America.

CETRARIA Ach. Meth. Lich. 292. *pl. 5. f. 3.* 1803.

The thallus is usually more or less ascendant. It may be either fruticose or foliose, and when the former it may be cylindrico-compressed or more or less channeled. The strictly fruticose forms are usually alpine, and our Minnesota species, except *Cetraria islandica*, are foliose, and closely adnate or more or less ascendant. In *Cetraria islandica* there is, as in the more foliose and prostrate forms, a well-developed cellular cortex on all sides; but in this species the algal layer is more scattered than usual in ours, being diffused throughout the medullary tissue or forming interrupted layers beneath the cortex on both sides of the thallus, while in our other species the algal cells are to be found in a definite layer just below the upper cortex. The thallus varies greatly in color.

The apothecia are disk-shaped or somewhat irregular in form, sessile and subpedicellate, terminal or marginal on the thallus, the disk differing from the thallus in color. The paraphyses and asci are rather short, composing a rather thin hymenium.

The spores are hyaline, simple, rather small, subellipsoid to subspherical in form.

Through the more erect forms the genus shows a close relationship to *Evernia* and indirectly with *Usnea*, while through the more foliose, less ascendant species the relationship with *Parmelia* is close.

Cetraria is represented in Minnesota by six species, of which *Cetraria ciliaris* is the only one generally distributed over the State.

The plants occur on trees, old wood, rocks, and earth.

Type species *Cetraria lacunosa* Ach. loc. cit.

KEY TO THE SPECIES.

- Thallus becoming fruticose..... 1. *C. islandica*.
 Thallus foliose.
 Thallus usually straw-colored or greenish.
 Thallus straw-colored, varying toward sea-green; whitish below..... 5. *C. aurescens*.
 Thallus scarcely varying from straw-colored above; yellowish below..... 6. *C. juniperina pinastri*.
 Thallus neither straw-colored nor greenish.
 Thallus large, reaching 90 mm. in diameter.
 Thallus becoming brownish, inconspicuously lacunose; margins ciliate..... 2. *C. ciliaris*.
 Thallus sea-green, conspicuously lacunose; margins not ciliate..... 4. *C. lacunosa*.
 Thallus small, not surpassing 15 mm. in diameter..... 3. *C. saepincola*.

1. *Cetraria islandica* (L.) Ach. Meth. Lich. 293. 1803.

Lichen islandicus L. Sp. Pl. 1145. 1753.

Thallus tufted, fruticose and subfoliose, rigid, variously laciniate, longitudinally grooved (canaliculate) or the margins here and there connivent or even uniting, bearing cilia or spinules at the margins, and more or less covered with impressed white soredia on the outer side of the longitudinal furrows, shining, pale chestnut to olivaceous or brown toward the top and frequently paler or sanguineous toward the base, 3 to 8 cm. in length in ours (foreign specimens in the writer's herbarium reaching 12 cm.); apothecia reaching 1.5 to 14 mm., sessile at the tips of the lobes, the thalloid margin entire or crenulate, thin or disappearing, the disk brown or chestnut, concave, flat, convex or irregular; hypothecium pale or pale brownish; hymenium brownish above and pale or brownish within; paraphyses usually simple, brownish and somewhat thickened toward the apex; asci cylindrical to cylindrico-clavate; spores oblong-ellipsoid, 6 to 10 μ long, 3.5 to 5 μ wide.

Once recorded for the State from the palisades on the north shore of Lake Superior, where it occurs on humus over rocks. Noted in a depauperate condition on old wood at Grand Portage in 1902. Common on Isle Royale. The soredia are absent in the specimen in the writer's herbarium from Minnesota, but are present in much of the material from Isle Royale. Agassiz and Macoun have both found the subspecies *Cetraria islandica delisei* Schaer.^a along the north shore of Lake Superior, and it may well be looked for in Minnesota. The writer has also a specimen of the species collected by Parry in Minnesota or Wisconsin in 1848.

Distributed throughout all the grand divisions except possibly Africa. Common in frigid regions and reaching warmer territory in mountains or along cold coasts. More or less common in such regions in North America.^b

2. *Cetraria ciliaris* Ach. Lich. Univ. 508. 1810.

Thallus foliose, 25 to 90 mm. in diameter, sinuously or laciniately lobed, the lobes crowded and ascendant, often narrow and many-cleft, more or less lacunose, their margin crenate and bearing scattered cilia or fibrils; sea-green to brownish above, more or less fibrillose and of the same color or lighter beneath; apothecia reaching good size, 1.5 to 12 mm. or more in diameter, sessile on the margins of the lobes, commonly more or less concave, the disk chestnut-brown or paler, the margin crenulate; hypothecium pale; hymenium brownish above and pale or brownish below; paraphyses simple or branched, somewhat thickened and frequently brownish toward the apex; asci cylindrico-clavate; spores subspherical, 5 to 7 μ long and 4 to 5 μ wide.

^a Enum. Lich. Eur. 15. 1850.

^b The "Iceland moss." See p. 35.

Occurs in all parts of the State; common in the northern part but rare southward. On trees, occasionally on old wood, and once on sandstone.

The plant occurs throughout the United States, and also northward, but usually in a dwarfed condition tending toward the next species. The species is strictly American, having been sent to Acharius by Muhlenberg. Nylander records it from Peru; otherwise only known in North America.

3. *Cetraria saepincola* (Ehrh.) Ach. Meth. Lich. 297. 1803.

Lichen saepincola Ehrh. Hannover. Mag. 206. 1787.

Thallus foliose, small, scarcely exceeding 5 to 15 mm. in diameter (the plants usually densely clustered along small twigs, the limits of individual plants thus difficult to determine), the lobes few and short, prostrate or somewhat ascending, smooth or more or less rugose, their margins undulate, crenate, or incised; olivaceous or brown above and paler beneath, without fibrils; apothecia rather small, 0.7 to 4 or possibly 5 mm. in diameter, sessile on the margins of the lobes, frequently numerous and almost completely obscuring the small lobes, the disk of the same color as the thallus or darker brown, usually concave, the thalloid margin entire or crenulate and usually disappearing; hypothecium pale; hymenium brownish above and gradually becoming pale or paler brownish beneath; paraphyses conspicuously jointed, simple or branched, pale or brownish, and usually thickened toward the apex; asci cylindrico-clavate; spores short-ellipsoid, 7 to 9.5 μ long and 4 to 6 μ wide.

Once collected in the State, along the shore of South Fowl Lake, on the northern boundary. Also found on Isle Royale in 1902. On small twigs.

Essentially an arctic plant, occurring in the northern portions of North America, and farther south in mountains and along cold shores. Also reported from the extreme southern portion of South America and in northern Europe and Asia.

4. *Cetraria lacunosa* Ach. Meth. Lich. 295. *pl. 5. f. 3.* 1803.

Thallus foliose, middle-sized or large, 5 to 14 cm. in diameter, the lobes crowded, quite wide and rounded, ascending, with crenate or lacerate margins, sea-green and reticulate-lacunose above, lighter-colored or sometimes blackening beneath, without marginal cilia; apothecia often quite numerous, reaching good size, 1 to 10 mm. in diameter, sessile or subpedicellate on the margins of the lobes, frequently perforate at the center, the perforation extending through the thallus lobe also, the disk chestnut-brown, concave, with a thin entire thalloid margin which sometimes finally disappears; hypothecium pale; hymenium brownish above and gradually becoming paler within; paraphyses simple or branched, pale or brownish, frequently somewhat thickened toward the apex; asci clavate or cylindrico-clavate; spores short, oblong-ellipsoid, 5 to 8 μ long and 4 to 5 μ wide.

Common in the northern part of the State, but not known to exist in the southern half or two-thirds. On trees.

The plant is strictly North American and is common on trees and rails in the northern half of the United States, and found also in British America, Alaska, and farther south in the mountains. Not known to be confined to especially cold regions, though its distribution in Minnesota would seem to indicate this, it being especially common in the northeastern portion of the State. This distribution would seem to indicate that our plant might be the closely related *Cetraria glauca* (L.) Ach., though its characters are plainly those of the present species.

5. *Cetraria aurescens* Tuck. Syn. Lich. N. E. 16. 1848.

Thallus foliose, middle-sized or smaller, 15 to 60 mm. in diameter, the surface quite smooth, sinuously or laciniately lobed, the lobes many-cleft, the ascendant margins crisped; straw-colored varying toward sea-green above, beneath whitish and clothed more or less with whitish or pale brownish fibrils; apothecia of good size, 1 to 7 mm. in

diameter, subpedicellate on the margins of the lobes, the disk brown, concave, the thalloid margin crenulate, rarely disappearing; hypothecium pale; hymenium pale or brownish above and pale below; paraphyses simple or rarely branched, with conspicuous joints, the apex brownish and somewhat thickened; asci clavate; spores short-oblong or subspherical, 4 to 5.5 μ long and 3 to 4 μ wide.

Widely distributed in northern Minnesota, though rather rare. Along the shore of Lake Superior, extending as far south as Duluth, where it was collected by Anna M. Kimball. On conifers, especially cedars.

A North American plant and, outside of Minnesota, only known in the eastern United States.

6. *Cetraria juniperina pinastri* (Scop.) Ach. Meth. Lich. 298. 1803. PLATE 36, B.
Lichen pinastri Scop. Fl. Carn. ed. 2. 2: 382. 1772.

Thallus foliose, small or middle-sized, 15 to 80 mm. in diameter, with crowded, more or less lacunose, crisped, erose-crenate, ascendant lobes; greenish to straw-colored above and pale yellow below, sometimes bright yellow toward the margins of the lobes, these clothed more or less with bright yellow soredia; apothecia middle-sized, 2 to 6.5 mm. in diameter; hypothecium pale; hymenium pale or brownish above and pale beneath; paraphyses commonly simple, the apex pale or brownish, and usually thickened; asci clavate; spores short-ellipsoid or subspherical, 5 to 7.5 by 4 to 5.5 μ .

In the fruited specimen of the species from which the above macroscopic characters were taken, the apothecia are submarginal and subpedicellate, the disk chestnut-brown, and the thalloid margin crenulate. The plant examined microscopically was from Natick, Massachusetts, collected by Clara E. Cummings.

Quite common in the northern part of the State. On trees, old wood, and rarely on rocks.

The species is common in the eastern United States and occurs along the west coast. Also found in British America and Alaska. The subspecies is alpine and descending. Occurs most commonly in our mountainous regions, both eastern and western. Also occurs in northern Europe and Asia and farther south in mountains.

EXPLANATION OF PLATE 36.—See page 195.

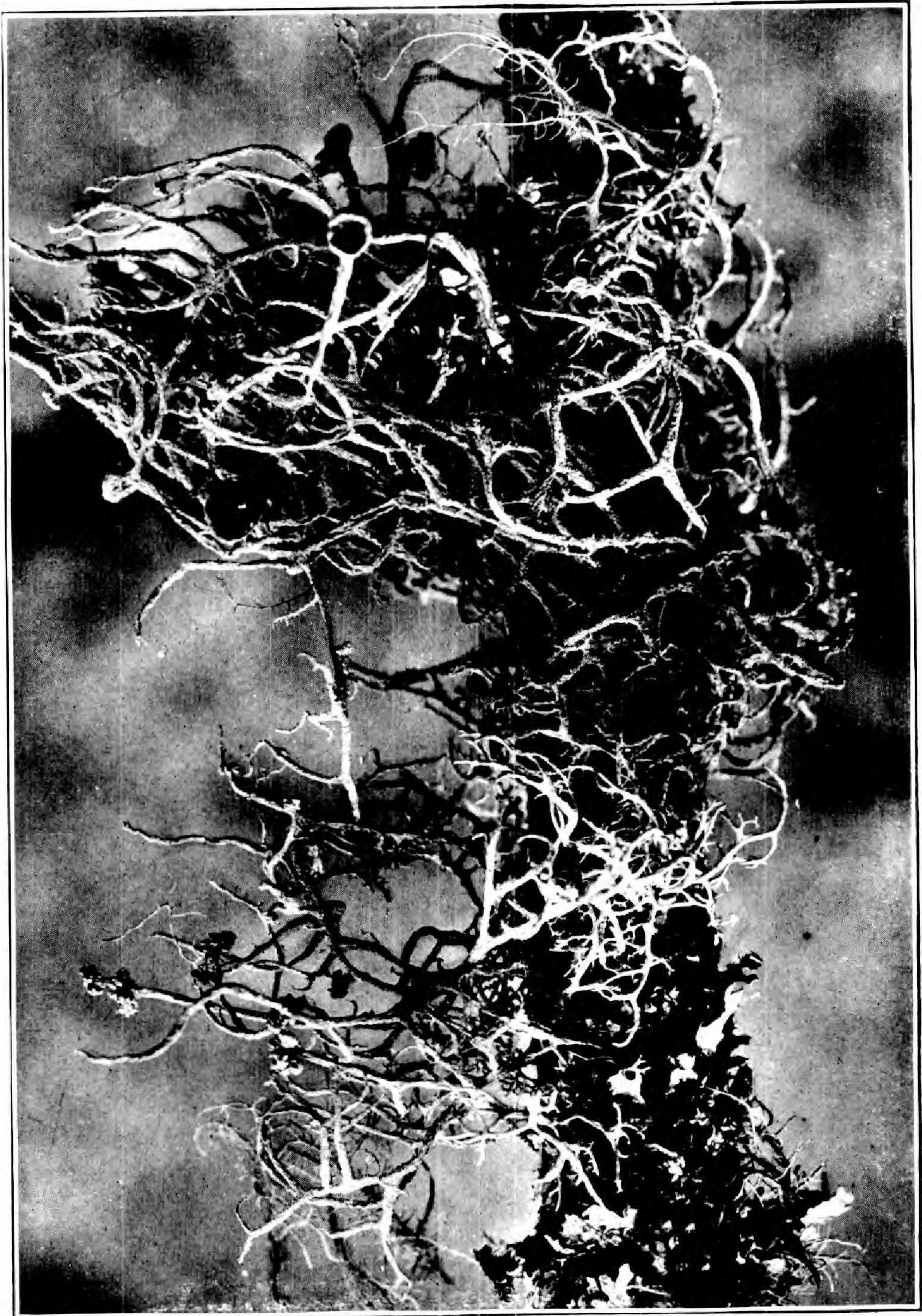
EVERNIA Ach. Lich. Univ. 84, 441. *pl. 10. f. 1-3.* 1810.

The thallus is more strictly fruticose than that of the more foliose *Cetrarias*, with which the genus is more or less closely related. Some of the species show a tendency toward a cylindrical form of thallus with radial arrangement of tissue layers. Branching is often dichotomous, and the thallus does not show the shining surface so characteristic of *Cetrarias*. The outer pseudocortex consists of an irregular network of hyphæ, which commonly extends vertical to the surface. Inside of this layer is the algal layer, consisting of rather large cells. Next within the algal layer lies the medullary layer, composed of loosely interwoven hyphæ and frequently hollow toward the center of the thallus. Within the medullary tissue lie closely packed longitudinal hyphæ in the form of a more or less complete hollow cylinder or forming a number of bundles. This cylinder of longitudinal hyphæ, or the bundles which replace it in some species, may be entirely wanting. The color is sea-green or yellow.

The apothecia are orbicular, large, and commonly terminal or subterminal with thalloid margin, the disk concave and of a color differing from that of the thallus. The hypothecium is pale and consists of two layers. The hymenium, in ours at least, is brownish above and pale or pale brownish below. The spores are hyaline, simple, more or less ellipsoid.

Only two species are certainly known in the State, though a third, *Evernia vulpina* (L.) Ach.,^a was collected in Minnesota or Wisconsin in 1848 by C. C. Parry.

^aLich. Univ. 443. 1810.



EVERNIA PRUNASTRI (L.) ACH.

The plants occur on trees, old wood, and rarely on rocks.

Type species *Evernia prunastri* (L.) Ach. loc. cit.

KEY TO THE SPECIES.

Thallus commonly sorediate and frequently isidioid, pale below... 2. *E. prunastri*.

Thallus not sorediate, but usually softish isidioid (furfuraceous),

for the most part black or black-spotted below..... 1. *E. furfuracea*.

1. **Evernia furfuracea** (L.) Mann. Lich. Bohem. 105. 1826.

Lichen furfuraceus L. Sp. Pl. 1146. 1753.

Thallus fruticose or subfoliose, 15 to 60 mm. long in our Minnesota specimens, though the species is frequently much longer, ascending, prostrate or pendulous, compressed, dichotomously and subpinnately lobed, the lobes tufted and frequently long, usually covered more or less with soft isidioid branchlets or tubercles above (furfuraceous), commonly channeled and lacunose below; sea-green to grayish above, beneath whitish, black-spotted or for most part black; apothecia rather large, 2 to 12 mm. in diameter, frequently short-pedicellate, terminal or lateral, disk deeply concave and brown, the margin usually entire but somewhat irregular; hypothecium pale; hymenium brownish above, pale brownish or pale below; paraphyses simple or rarely branched, with apex pale and scarcely thickened; asci clavate; spores 6.5 to 7.5 μ long and 4 to 5 μ wide, oblong-ellipsoid.

Occurring rarely in the northeastern portion of the State. On cedars. Ours sterile.

The species occurs in the northern United States and Canada and southward in the mountains. Also reported from Florida by Calkins. Known in cold portions of all the grand divisions except Australia.

2. **Evernia prunastri** (L.) Ach. Lich. Univ. 442. *pl. 10. f. 1.* 1810. PLATE 39.

Lichen prunastri L. Sp. Pl. 1147. 1753.

Thallus fruticose, tufted, ascending, prostrate, or long and pendent, rounded, somewhat angular or flattened, sometimes channeled below, much branched dichotomously and divaricately, the branches sometimes becoming long, lacunose, commonly more or less sorediate and frequently bearing isidioid branchlets, straw-colored to pale sea-green or paler below, 15 to 85 mm. long; apothecia of medium size in the two fruited specimens from the State, 4 to 8 mm. in diameter, sessile or subpedicellate on the margins of the branches, concave, the disk brown and the thalloid margin entire; hypothecium pale; hymenium brownish above and pale brownish below; paraphyses simple or possibly rarely branched, apex pale and scarcely thickened; asci clavate; spores ellipsoid, 5.5 to 7 μ long and 3 to 4 μ wide.

Generally distributed over the State, but hardly common. On trees, old wood, and rarely on rocks. Found fruited but twice.

Occurs throughout the northern United States and British America. The plant is known in all the grand divisions except, possibly, Australia.

EXPLANATION OF PLATE 39.—Plant on the limb of a tree showing the fruticose thallus and the very rare apothecia. Natural size.

RAMALINA Ach. Lich. Univ. 122, 598. *pl. 13. f. 5-11.* 1810.

PLATE 40.

The thallus is fruticose and flattened. The pseudocortex consists of closely packed hyphæ, extending wholly or for the most part in the direction of the long axis of the thallus. The medullary portion consists of loosely interwoven hyphæ which, in some species, run mostly in the direction of the long axis of the thallus and are seldom united with the cortical hyphæ, while in other species (all of ours) they run in various directions and are commonly united with the cortical hyphæ. The algal layer extends around wholly within the cortex in the form of a hollow flattened cylinder.

The apothecia are upon one side of the thallus (upper when the branches are not erect), along the margin or terminal or subterminal, subpedicellate, with entire

thalloid exciple, the disk pale, the hypothecium pale, the hymenium of the same color or tinged with brown. The hypothecium consists of two layers. The spores are hyaline, oblong to ellipsoid, and 2-celled.

The phyletic relations of the genus are by no means known. In superficial appearance the plants are perhaps most like those of the genus *Roccella*, but the two genera are not closely related anatomically. Morphologically *Ramalina* is much more closely related to *Usnea* and *Evernia*.

The genus is represented in Minnesota by seven quite distinct forms. *Ramalina calicaris*, in some of its forms, is the most common species in the State, through *Ramalina pusilla* is common enough in the northern portion.

Ramalinas may be looked for on trees, old wood, and rocks.

Type species *Ramalina homalea* Ach. loc. cit.

EXPLANATION OF PLATE 40.—Fig. 1, the plant, showing the lobed thallus and the apothecia. Fig. 2, a portion of the thallus and three apothecia. Fig. 3, a section through an apothecium and the thallus below; *a*, the hymenium; *b* and *c*, the hypothecium; *d*, the algal layer; *e*, the medullary layer; *f*, the algal layer; *g*, the pseudocortex of entangled hyphæ. Fig. 4, a longitudinal section of the thallus; *a* and *f*, the pseudocortex; *b* and *e*, the algal layer; *c* and *d*, the medullary layer. Fig. 5, paraphyses and an ascus. Fig. 6, two-celled spores. Fig. 7, algal cells. Fig. 1, natural size; fig. 2, enlarged about 10 diameters; figs. 3, 4, enlarged 400 diameters; figs. 5-7, enlarged 650 diameters. From Schneider.

KEY TO THE SPECIES.

Thallus neither sorediate nor hollow within (inflated).

Thallus much branched, the lobes narrow.

Thallus lobes conspicuously canaliculate..... 1b. *R. calicaris canaliculata*.

Thallus lobes not canaliculate..... 1. *R. calicaris*.

Thallus less branched, the lobes wider..... 1a. *R. calicaris fraxinea*.

Thallus lobes either sorediate or inflated.

Thallus lobes sorediate.

Thallus lobes sorediate throughout..... 1c. *R. calicaris farinacea*.

Thallus lobes sorediate especially toward the tips..... 2. *R. polymorpha*.

Thallus lobes inflated.

Tips of the lobes deflexed..... 3a. *R. pusilla geniculata*.

Tips of the lobes not deflexed..... 3. *R. pusilla*.

1. ***Ramalina calicaris*** (L.) Fr. Lich. Eur. 30. 1831.

PLATE 41, A.

Lichen calicaris L. Sp. Pl. 1146. 1753.

Thallus 5 to 60 mm. long, somewhat rigid, composed of tufted lobes, compressed, usually more or less lacunose, the lobes numerous and crowded, narrow and dichotomously branched above, gray to sea-green; apothecia 1 to 6 mm. in diameter, depressed-flattish, subpedicellate, lateral, terminal or lateral near the apex, sea-green to flesh-colored; paraphyses more or less branched, pale and slightly thickened at the apex; asci clavate; spores oblong to ellipsoid, straight or slightly curved, 9 to 18 μ long and 4 to 7 μ wide.

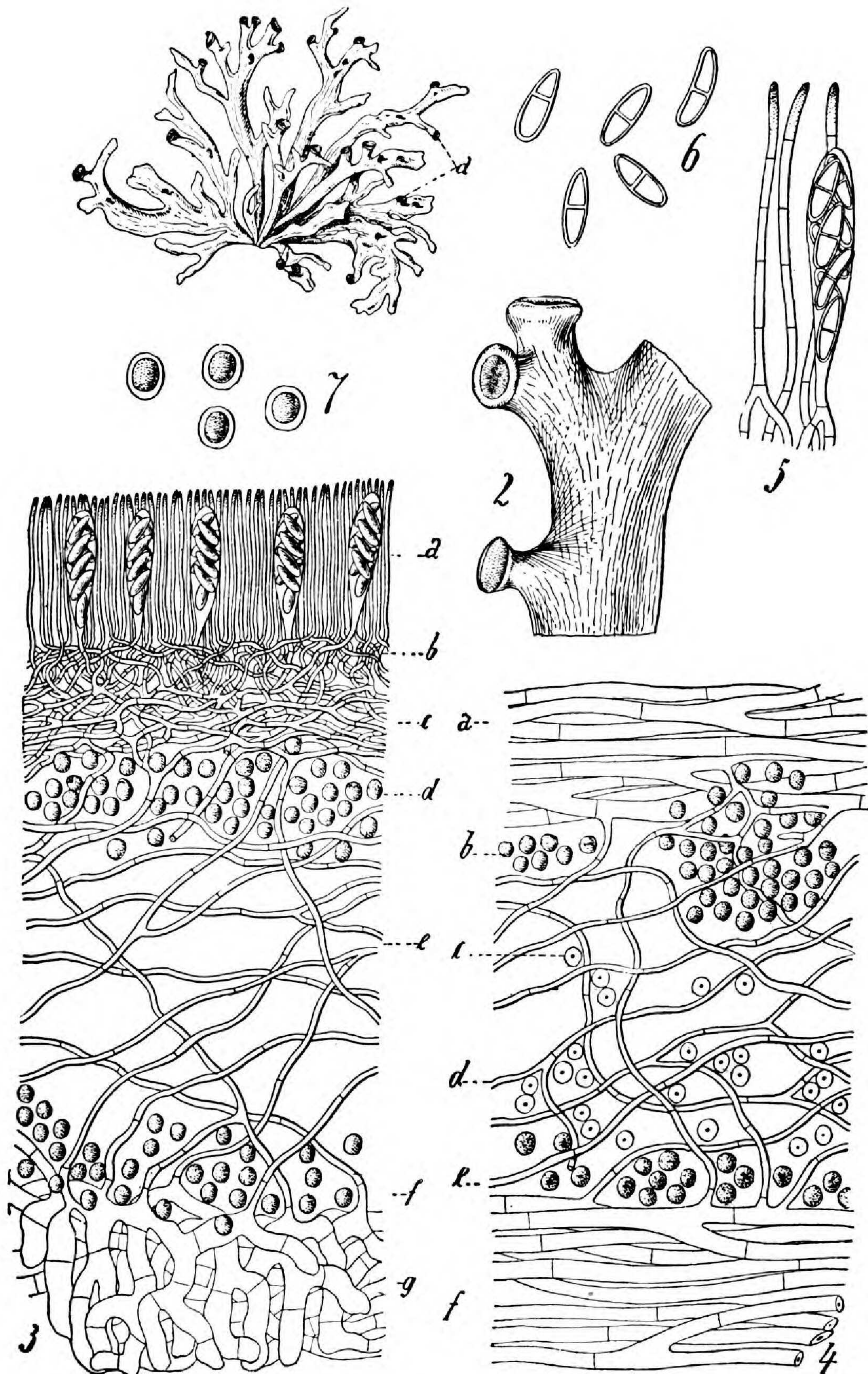
Frequent throughout the State. On trees, old wood, and rarely on rocks.

Ramalina calicaris fastigiata of the preliminary reports.

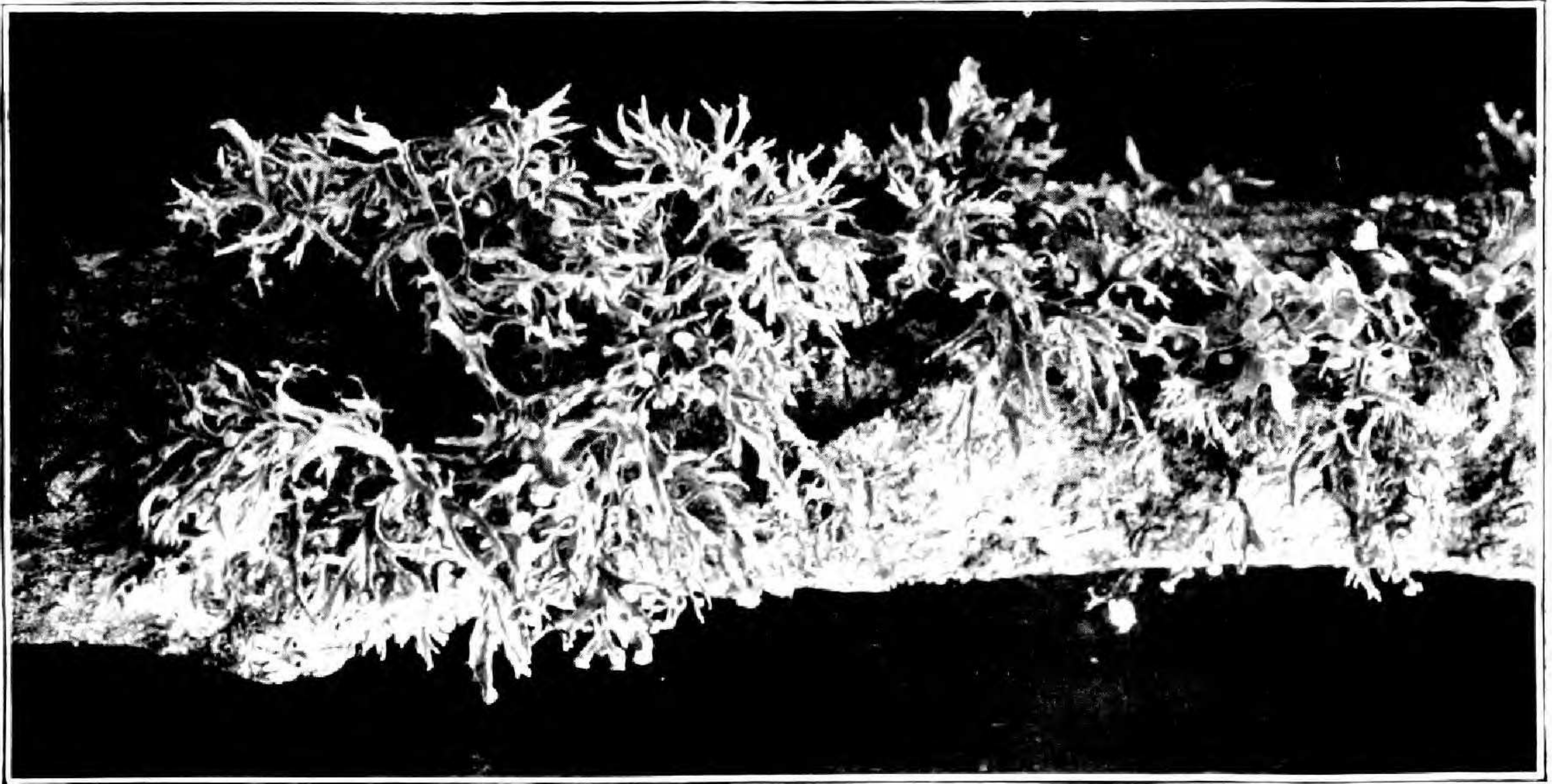
EXPLANATION OF PLATE 41.—A, Plants of *Ramalina calicaris* on the limb of a tree showing the foliose thallus and the apothecia. B, Plant of *R. pusilla*, rapidly replacing *Lecanoras* and *Biatoras* on the limb of a balsam fir. A natural size; B enlarged 2 diameters.

1a. ***Ramalina calicaris fraxinea*** (L.) Fr. Lich. Eur. 30. 1831.

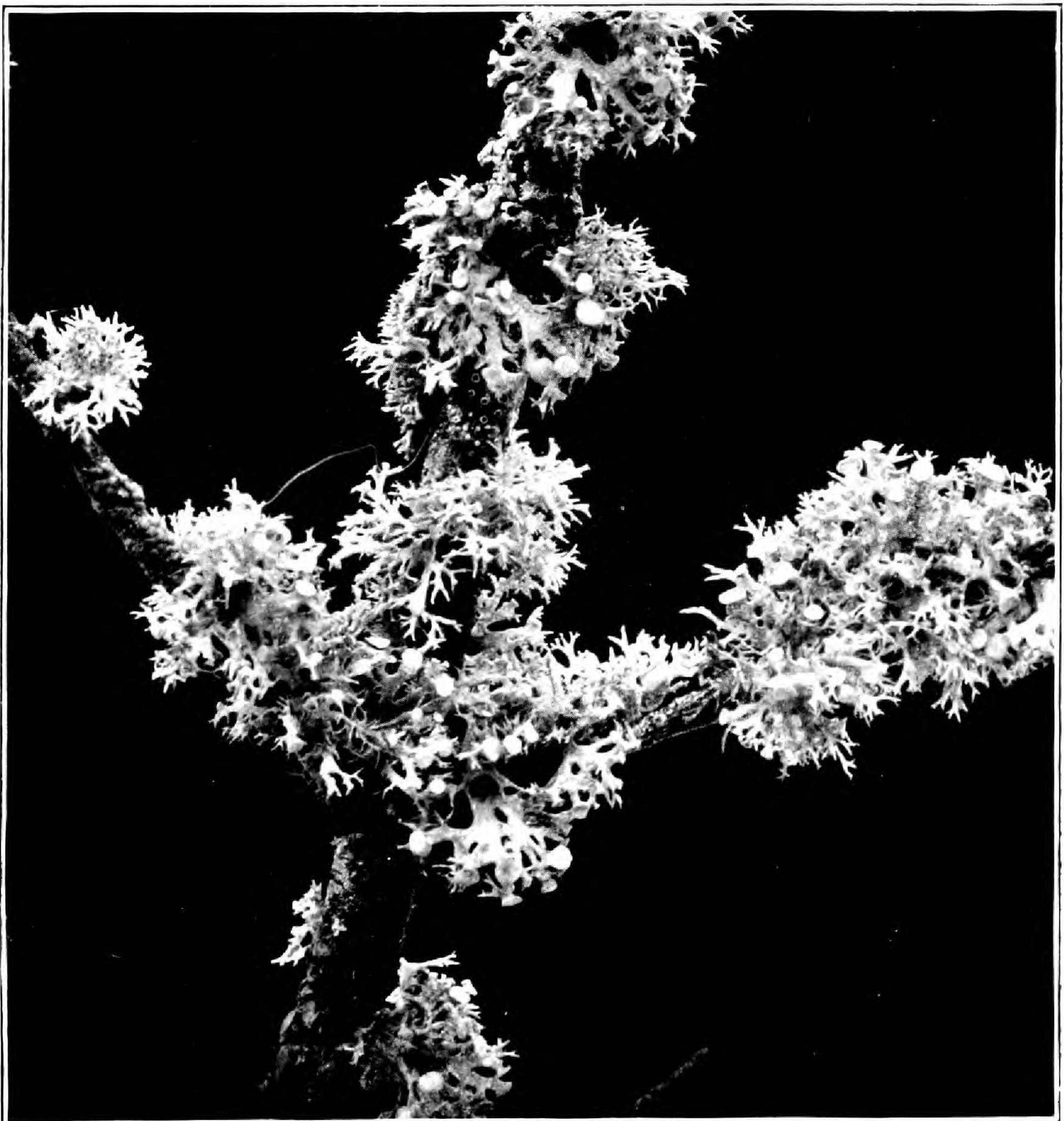
Lichen fraxineus L. Sp. Pl. 1146. 1753.



RAMALINA CALICARIS (L.) FR.



A. RAMALINA CALICARIS (L.) FR.



B. RAMALINA PUSILLA PREV.

Lobes few and wide, subsimple and frequently quite long; apothecia in the more distinct wide-lobed forms laterally placed on one side of the thallus and frequently larger than in other subspecies, sometimes surpassing the measurements given above. Extreme forms quite distinct, but passing into the next subspecies.

Occurs in all parts of the State except the northeastern portion, but is rare except in the southeastern part. On trees and old wood.

Widely distributed in North America. Also common in all the grand divisions except Australia. Foreign specimens sometimes twice as long as our Minnesota plants.

1b. *Ramalina calicaris canaliculata* Fr. Lich. Eur. 30. 1831.

The lobes much as in the last as to number, branching, and length, but even narrower and with a conspicuous longitudinal groove on one side (canaliculate); apothecia of the same size as in the last above, but attached just below the usually long and geniculate tips.

A single locality in the State, Snowbank Lake, in the extreme northern part. On trees.

American and foreign distribution about the same as that of the last, but the plant is more rare in most localities.

1c. *Ramalina calicaris farinacea* (L.) Nyl. Act. Soc. Linn. Bord. 21: 293. 1856.

Lichen farinaceus L. Sp. Pl. 1146. 1753.

Thallus lobes frequently narrower than in the last, usually smoother, frequently becoming quite long and slender, covered more or less with usually conspicuous white soredia; apothecia lateral or terminal, rare.

Occurs in all parts of the State, but is rarely seen in fruit. On rocks and rarely on trees.

Common to all the grand divisions, both in frigid and warmer regions. The plant frequently reaches 12 to 14 cm. in length in Europe.

2. *Ramalina polymorpha* Ach. Lich. Univ. 600. 1810.

Lichen polymorphus Ach. Vet. Akad. Handl. 18: 270. *pl. 11. f. 3.* 1797.

Thallus 10 to 40 mm. long, somewhat rigid, smooth or longitudinally rugose, composed of tufted lobes, compressed; lobes few or many, narrow (in ours scarcely more than 2 to 4 mm. wide) and sprinkled more or less, especially toward the apices, with conspicuous soredia; apothecia 2 to 5 mm. in diameter, slightly concave, pale yellowish or more or less white-pruinose, subpedicellate and subterminal; paraphyses somewhat branched or simple, the apex slightly thickened but scarcely colored; asci cylindrico-clavate; spores oblong, straight, 11 to 15 μ long and 4 to 5 μ wide.

The above microscopic characters were taken from European plants and from number 763 collected in 1897 at the Palisades, north shore of Lake Superior.

The plant from the Palisades is the only undoubted specimen of the species collected thus far in Minnesota. Others from Granite Falls and Rainy Lake City seem nearer the last above. On rocks.

Little is known of the plant in North America. More or less common in Europe, Africa, and Australia.

3. *Ramalina pusilla* Prev. in Fr. Lich. Eur. 29. 1831.

PLATE 41, B.

Thallus small, about 7 to 13 mm. long, somewhat rigid, smooth or more or less reticulated, composed of tufted lobes, these rounded or compressed, hollow-inflated, only 1 to 2 mm. wide; apothecia small, 0.5 to 2 mm. in diameter, plane or somewhat concave, pale yellowish or whitish, sessile or subpedicellate, commonly subterminal; paraphyses more or less branched, pale and slightly thickened toward the apex; asci short-clavate; spores oblong to ellipsoid, straight or slightly curved, 11 to 16 μ long and 5 to 7 μ wide.

Found in the northern portion of the State and almost wholly confined to balsams.

In North America confined for most part to arctic and subarctic regions. Known also in South America, Europe, Africa, and Australia. Some of Arnold's European plants are much larger than ours.

EXPLANATION OF PLATE 41.—See page 204.

3a. Ramalina pusilla geniculata (Tayl. & Hook.) Tuck. Syn. N. A. Lich. 1: 26. 1882.

Ramalina geniculata Tayl. & Hook. Lond. Journ. Bot. 3: 655. 1844.

Thallus more commonly compressed, smooth, subdichotomously and frequently much branched, sometimes bearing soredia, the tips of the lobes deflexed.

Occurring with the last, but less common.

North and South American distribution about the same as that of the species. Also known in Europe and Australia.

ALECTORIA Ach. Lich. Univ. 120, 592. *pl. 13. f. 1-4.* 1810.

The thallus is strictly fruticose and cylindrical or compressed-cylindrical, more commonly the latter at the points of branching, and may be erect, spreading, or pendent. Branching is frequent and usually dichotomous or subdichotomous. The pseudocortex consists of a thick layer of stout hyphæ, running for most part parallel in a longitudinal direction, and forming a hollow cylinder, which in some forms is quite rigid, the hyphæ composing a tissue which functions as stereome. The outer hyphæ of the cylinder are usually colored and stronger, the whole structure, however, as is common among lichens, becoming flexible when wet. Within the cortex is the algal layer, consisting of rather scattered clusters of algæ, which form an incomplete hollow cylinder within the cortex. The medullary tissue consists of loosely interwoven hyphæ, traversing the space within the cortex and united here and there with its inner hyphæ. In some species the cortical layer is thinner and the medullary layer traversed by a number of small bundles of longitudinal hyphæ. The color is brown, blackish brown, straw-colored, or sea-green, a given species differing greatly in color and even a given plant at different ages.

The apothecia are rather rare in most of the species, lateral and sessile or immersed, the disk of different color from that of the thallus, the margin usually entire. The hypothecium is pale and consists of two distinct layers. The hymenium is usually pale or slightly colored below and darker above. The paraphyses are usually simple. The spores are simple (the genus in the Tuckermanian sense also including species having compound spores), colorless, or becoming brownish, 2, 3, 4, or 8 in each ascus.

The genus seems to be very closely related to *Usnea*.

A single species, with two subspecies, occurs in the State. On trees and old wood.

Type species *Alectoria jubata* (L.) Ach. loc. cit.

KEY TO THE SPECIES.

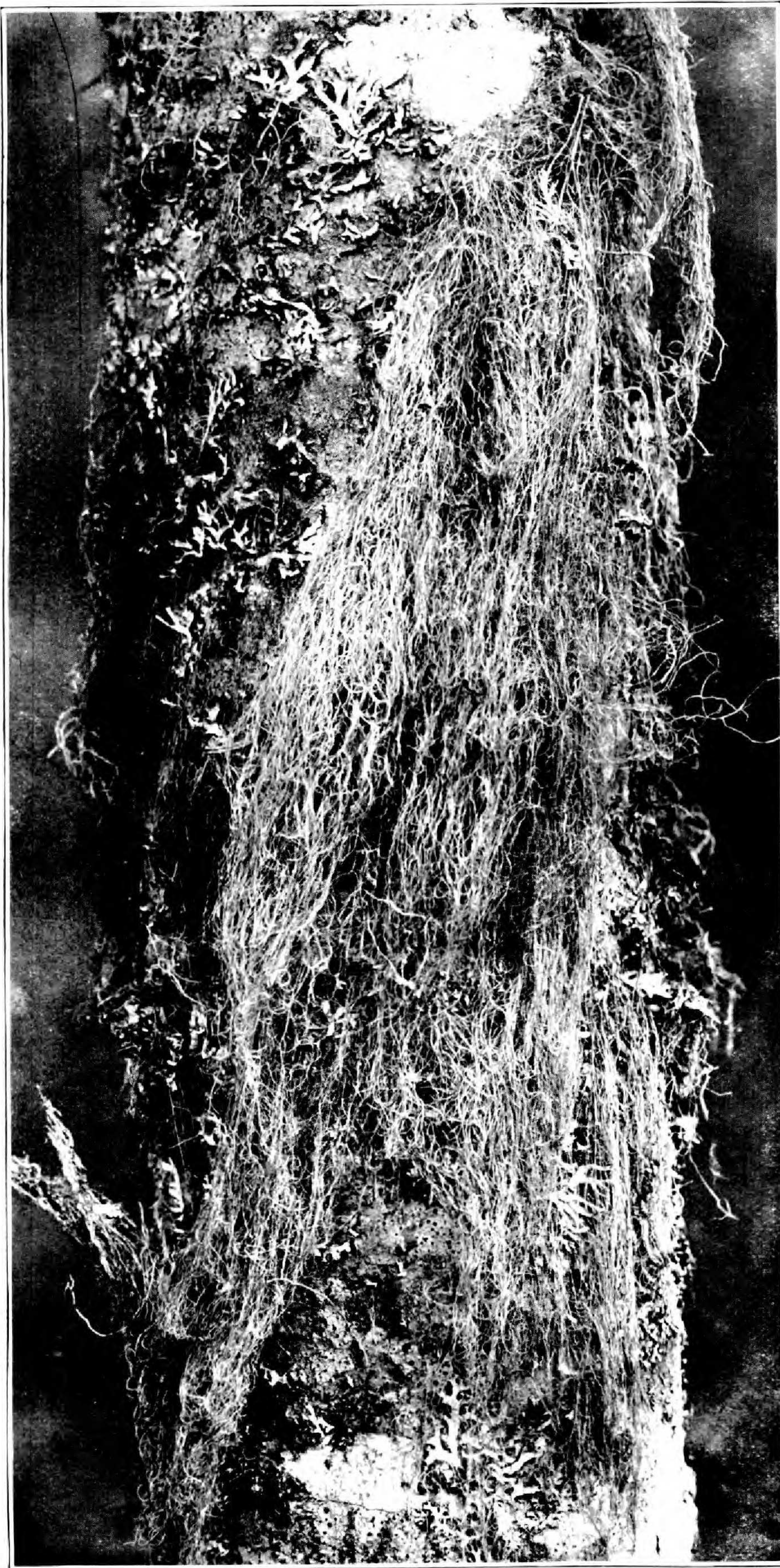
- Thallus rather short, spreading, prostrate, or subpendent, commonly sorediate..... 1a. *A. jubata chalybeiformis*.
- Thallus long and pendent.
- Thallus freely branching dichotomously, brown or sometimes in part or wholly sea-green..... 1. *A. jubata*.
- Thallus much elongated, more freely branched and the branches intertangled, brown or darker throughout.... 1b. *A. jubata implexa*.

1. Alectoria jubata (L.) Ach. Lich. Univ. 592. *pl. 13. f. 2.* 1810.

Lichen jubatus L. Sp. Pl. 1155. 1753.

PLATE 42, A.

Thallus tufted, slender, long and pendent, freely branching dichotomously, sub-cylindrical, brown, blackish brown, or sometimes wholly or in part sea-green; ours



A. ALECTORIA JUBATA (L.) ACH.

B. USNEA LONGISSIMA ACH.

at least seldom if ever sorediate, 5 to 17.5 cm. long; apothecia chestnut-brown, plane or convex, small, 1 to 2 mm. in diameter; spores colorless (possibly becoming brownish), short-ellipsoid, 6 to 9 μ long and 4 to 5 μ wide.

Ours sterile, and the data regarding apothecia taken principally from Nylander.

Common in the northern portion of the State, the first subspecies being the only form thus far known farther south in Minnesota. However, the above-described form has been found in northeastern Iowa and doubtless occurs in southeastern Minnesota. Ours on trees, but on sandstone in Iowa.

Distributed throughout North America, but usually confined to mountains southward. Usually sterile except in mountains or at the extreme north. Generally distributed throughout all the grand divisions.

EXPLANATION OF PLATE 42.—A, Plant of *Alectoria jubata* on trunk of a balsam fir, showing the pendulous fruticose thallus. B, Plant of *Usnea longissima* hanging from the limb of a tree, containing strands several feet long. A natural size; B, about one-eighth natural size.

1a. *Alectoria jubata chalybeiformis* (L.) Ach. Lich. Univ. 593. 1810.

Lichen chalybeiformis L. Sp. Pl. 1155. 1753.

Thallus shorter, spreading, prostrate, or subpendulous, more rigid than the species, rather remotely and divaricately branched, flexuous, brown or brownish sea-green, commonly more or less sorediate, usually sparingly fibrillose, especially along the smaller branches, the fibrils frequently occurring several in a cluster, shorter than in the type, 15 to 85 mm. long.

Ours is uniformly sterile, and no statement of apothecial characters could be found. Probably worthy of specific rank, but perhaps may best stand as a subspecies in the absence of spore characters, etc.

The most common form in Minnesota and quite generally distributed over the State. On trees and no doubt yet to be found on rocks.

Common throughout the northern United States, Alaska, and British America; fertile in mountains. Also distributed throughout northern Europe and Asia.

1b. *Alectoria jubata implexa* (Hoffm.) Ach. Lich. Univ. 593. 1810.

Usnea implexa Hoffm. Deutsch. Fl. 2: 134. 1795.

Thallus pendent and slender, much branched and intertangled, elongated 10 to 17.5 cm. long; brown throughout; apothecia not seen.

Collected in the Misquah Hills and at Beaver Bay, once in each locality. On trees.

Distributed throughout the Northern States and British America; fertile in mountains. Occurs also in Europe, though Nylander does not seem to recognize the subspecies.

USNEA (Dill.) Adans. Fam. Pl. 2: 7. 1763.

The thallus is fruticose and frequently very long. Besides being the longest of lichen thalli, it shows the greatest specialization of the fruticose type. Branching is common, and the main trunks and the branches are usually cylindrical though rarely angular. A pseudocortex is developed on all sides of the cylindrical thallus. Inside of the quite thick cortex lies the algal layer in the form of a hollow cylinder. The medullary tissue within is dimorphic, the center consisting of a solid cylinder of densely packed hyphæ, extending in a longitudinal direction, and surrounding this a cylinder of loosely interwoven hyphæ, uniting internally with the solid portion of the medullary tissue and externally with the cortex. The colors are sea-green or rarely straw-colored, varying to reddish brown.

The apothecia are orbicular, most frequently terminal or subterminal on the branches, the disk pale in all of ours, usually flat and thin, the thalloid margin bearing fibrils. The hypothecium and the hymenium are both pale. The spores are hyaline, simple, ellipsoid or rounded-ellipsoid, and scarcely differ enough in the various species to have much diagnostic value.

The genus seems closely related to Evernia and yet closer to Alectoria. Nine species and subspecies have been reported from Minnesota, of which *Usnea barbata* is the only one generally distributed over the State.

On trees, old wood, and rarely on rocks.

The Usneas are difficult to determine in some instances, and some of our species and subspecies are by no means certain.

Type species *Lichen plicatus* L. Sp. Pl. 1154. 1753. (*Usnea barbata plicata* (L.) Fr.)
Based on *Coralloides* Dill. Musc. pl. 11. f. 1. 1741, identified in L. Sp. Pl. 1154. 1753.

KEY TO THE SPECIES.

Thallus short, scarcely pendent.

Thallus sea-green or grayish.

Thallus usually erect, strigose-fibrillose..... 1. *U. barbata*.

Thallus longer and inclined to pendent conditions,
fibrillose and sorediate..... 1a. *U. barbata hirta*.

Thallus rusty red, otherwise similar to the last above..... 1b. *U. barbata rubiginosa*.

Thallus long and pendent.

Thallus stout and rigid.

Trunks angulate..... 2. *U. angulata*.

Trunks not angulate, quite fibrillose..... 1c. *U. barbata ceratina*.

Thallus more slender.

Thallus foveolate-lacunose toward the base..... 4. *U. cavernosa*.

Thallus not foveolate-lacunose.

Branches clothed with fibrils.

Fibrils long and numerous; the thallus very
long..... 3. *U. longissima*.

Fibrils shorter and less numerous..... 1d. *U. barbata dasy-
poga*.

Fibrils few or absent..... 1e. *U. barbata plicata*.

1. *Usnea barbata* Fr. Sched. Crit. Lich. Exsicc. Suec. 8:34. 1826.

Thallus fruticose, stout, erect or spreading, rather short, 20 to 60 mm. in length, rigid, branched divaricately, grayish to sea-green in color, more or less strigose, fibrillose, the branches and main trunks cylindrical; apothecia terminal or subterminal, varying considerably as to size, 3 to 10 mm. in diameter, commonly more or less concave, the disk pale flesh-colored or slightly brownish or reddish, the margin clothed more or less with fibrils, these also frequent on the under side; hypothecium pale; hymenium pale throughout; paraphyses simple or rarely branched, with pale and somewhat thickened tips; asci clavate or cylindrico-clavate; spores ellipsoid, 7 to 10 μ long and 5 to 6 μ wide.

Generally distributed in the State. On trees and old wood, and rarely on rocks. Commonly fruited in the southern part of the State, but not known to fruit northward in the State, though quite common.

This species occurs in all parts of North America and is quite cosmopolitan also in its foreign distribution. It is the *Usnea barbata florida* (L.) Fr.^a of most authors.

1a. *Usnea barbata hirta* (L.) Fr. Lich. Eur. 18. 1831.

Lichen hirtus L. Sp. Pl. 1155. 1753.

Thallus somewhat more slender and less rigid than the last, consequently less often erect but more inclined to be pendent, though not long; more or less fibrillose, with small fibrils and thickly sprinkled with soredia, of same color as the last.

^a Lich. Eur. 18. 1831.

Ours at least is uniformly sterile. One plant referred here, no. 716 from Emo, is a peculiar form, having larger fibrils and also unusually large soredia. It seems to be intermediate between this subspecies and the last above.

The most common subspecies, and to be looked for on trees in any part of the State.

Found in all parts of North America and Europe.

1b. *Usnea barbata rubiginea* Michx. Fl. Bor. Amer. 2: 332. 1803.

Thallus usually quite similar to that of the last, but sometimes more rigid, with stouter fibrils, differing in the rusty red color.

Our specimens are sterile. Acharius mentions the apothecia in *Lichenographia Universalis*. Nylander has not recognized this subspecies so far as the writer can ascertain, and it may well be doubted whether a subspecies should be founded upon the variation in color.

This form has been collected at Minneapolis, Taylors Falls, and Mankato on sandstone, also at Redwood Falls on granite. Is thus confined to the southern half of the State and for the most part to sandstone.

Strictly a North American subspecies.

1c. *Usnea barbata ceratina* (Ach.) Nyl. Syn. Lich. 1: 268. 1858.

Usnea ceratina Ach. Lich. Univ. 619. 1810.

Thallus rather stout and rigid but rather or very long and always pendent, branching freely, quite fibrillose, grayish to sea-green; apothecia absent from ours, said to be of middle size or even large.

Common in the northern part of the State, Henning being the most southern Minnesota station known. On trees.

The subspecies is distributed over all parts of North America, though its distribution in Minnesota would seem to indicate that it might be a northern form. Widely distributed in Europe and also known in Asia and South America.

1d. *Usnea barbata dasypoga* Ach. Lich. Univ. 624. 1810.

Usnea plicata dasypoga Ach. Meth. Lich. 312. 1803.^a

Thallus more slender and lax than in the last, as long or longer and not branching so freely, quite as fibrillose and of same color, in foreign specimens sometimes yellowish.

Nylander says "similis *floridæ*, sed thallo elongato pendulo," his brief description thus implying characters quite different from those ascribed to the subspecies by Acharius in his original description.

Collected only at Henning and at Rose Lake, but apparently common on trees at both localities. Doubtless quite frequent in the northern portion of the State, but easily overlooked on account of its close resemblance to the last above.

Distributed over the northern United States and British America and farther south in mountains. Widely distributed in Europe and occurring in Africa and Brazil.

1e. *Usnea barbata plicata* (L.) Fr. Lich. Eur. 18. 1831.

Lichen plicatus L. Sp. Pl. 1154. 1743.

Thallus pendent and much elongated, slender and lax, subdichotomously branched, paler in color, the fibrils absent or evanescent; apothecia absent in ours, said to be small and infrequent.

The form referred to here seems to be common about Ely, and a specimen was collected on Flag Island in Lake of the Woods. Not known farther south in the State. On trees.

^a *Dasypoga* was in the original misprinted as *dasopoga*.

Distributed over the northern part of the United States and over Alaska and British America, and farther south in the mountains. Also widely distributed in Europe and found in South America.

2. *Usnea angulata* Ach. Syn. Lich. 307. 1814.

Thallus fruticose, rather stout and rigid but much elongated and pendent, the main trunk at least more or less angulate and lacunose, branched rather remotely, at least toward the ends, thickly covered with rather long pointed fibrils, grayish to sea-green in color, 6 to 25 cm. long; apothecia absent from ours, but said to be small with flesh-colored disk bearing a white bloom. "Spores rounded-ellipsoid, 5 to 8 μ long and 4.5 to 5.5 μ wide." Other microscopic data not obtainable.

A single specimen has been collected in the State, viz, by Macmillan on a tamarack in a swamp near Minneapolis.

Widely distributed in the United States east of the western Cordilleras, and also frequently reported from South America. Otherwise only known on certain islands of the Southern Hemisphere.

3. *Usnea longissima* Ach. Lich. Univ. 626. 1810.

PLATE 42, B.

Thallus fruticose, varying in length from 10 to 150 cm., or even longer, the point of attachment to the substratum seldom to be found, the plants usually hanging free over the branches of trees, cylindrical or somewhat compressed, roughened, ours quite slender and lax, though other specimens are usually stouter, rather sparingly branched, clothed with usually long fibrils, these commonly horizontal and rather straight, light or darker sea-green; apothecia said to reach middle size, but small and terminal in specimens at hand, 1 to 2.5 mm. in diameter, the disk pale flesh-colored and concave, the margin bearing long fibrils; hypothecium pale; hymenium pale or brownish; paraphyses simple or branched, with pale but somewhat thickened apices; asci clavate to cylindrico-clavate; spores oblong-ellipsoid, 9 to 10 μ long and 4 to 5 μ wide.

Ours uniformly sterile, the above microscopic features of the apothecia taken from Arnold's European Exsiccati, no. 1685a.

Frequent along the north shore of Lake Superior and rarely occurring back from the shore near the northern boundary. On trees.

Distributed throughout northern United States, Alaska, and British America, especially in the mountains. Occurring in all the grand divisions.

EXPLANATION OF PLATE 42.—See p. 207.

4. *Usnea cavernosa* Tuck. in Agassiz, Lake Superior 171. 1850.

PLATE 43.

Thallus pendent, elongated, 10 to 35 cm. long, the basal enlarged portions often reaching 3 to 5 mm. in diameter, compressed-cylindrical or angulate, foveolate-lacunose toward the large basal portions of the main stems, rather sparingly branched below but much dichotomously branched above, the branches finally very small and much interwoven; scarcely fibrillose or the basal enlarged and somewhat compressed portions of the main trunks occasionally quite fibrillose, especially along the margins; light or darker sea-green; apothecia small to middle-sized, 1 to 6.5 mm. in diameter, seldom terminal; the disk pale flesh-colored and concave; the margin, in ours at least, quite strongly fibrillose with long fibrils; hypothecium pale; hymenium pale throughout; paraphyses somewhat distinct, simple or branched, with pale, thickened apices; asci clavate; spores ellipsoid or short-ellipsoid, 7 to 9 μ long and 4 to 5 μ wide in ours.

The plant is frequently found in the northeastern one-third of the State. On trees. Tuckerman's statement that the plant strongly resembles *Alectoria ochroleuca sarmentosa* Nyl. is well founded.

Distributed widely in British America, but in the United States confined for most part to mountainous regions. Also known in southern South America and in India.

EXPLANATION OF PLATE 43.—A spruce covered with Usneas and Alectorias, for the most part *Usnea cavernosa*, at Grand Portage. About one-thirteenth natural size.



USNEA CAVERNOSA TUCK.

Family **TELOSCHISTACEAE.**

This family consists of the two genera, *Placodium* and *Teloschistes*, though some lichenists have made more genera by further subdivision. The peculiarities of the family are the yellow or orange color, due to a deposit of chrysophanic acid commonly found in both thallus and apothecia, and the typically polar 2-celled spores, found constantly or sometimes in nearly all of the species of the two genera.

Of the two genera, *Placodium* with its commonly crustose thallus is plainly the lower, and the spore resemblance in the two would seem to indicate that members of the genus *Teloschistes* were derived phylogenetically from some species of *Placodium*. Also the algal symbiont *Cystococcus* is common to both genera.

Squamulose, foliose, and fruticose thalli occur in the family, and the apothecia are either adnate or sessile. The spores may rarely be nonpolar or even simple.

The relationship between the family and the Parmeliaceae was stated in the description of that family and need not be given here. In form and anatomy of the thallus, and in spores and apothecial characters, there is also a less close relationship between the present family and the Physciaceae, the nearest approach of the two families being in the genera *Teloschistes* and *Physcia*, *Placodium* and *Rinodina* being somewhat less closely related as to thallus structure, but equally close as regards the spores.

PLACODIUM (Hill) Web. in Wig. Prim. Fl. Hols. 90. 1780.

The thallus varies from subfoliose to strictly crustose forms, the latter being much more common. As in *Lecanora*, the thallus is closely adnate even in the best developed or subfoliose forms. In these the upper cortex is fairly well developed and commonly shows more or less of cellular structure, while the lower cortex is much thinner and more commonly composed of closely interwoven hyphæ. Even in the more crustose species an upper cellular cortex is often more or less developed, and on the whole these crustose thalli are better developed than the similar ones of the *Lecanoras*. Algal and medullary layers are also frequently demonstrable in sections, especially in the more foliose forms. Rhizoids or rhizoidal hyphæ are present as attaching organs, but are by no means common and are not often noticed in sections. The algal symbiont is *Cystococcus*. The common colors of the thallus are yellow and orange. Fruticose forms are admitted to the genus by some lichenists.

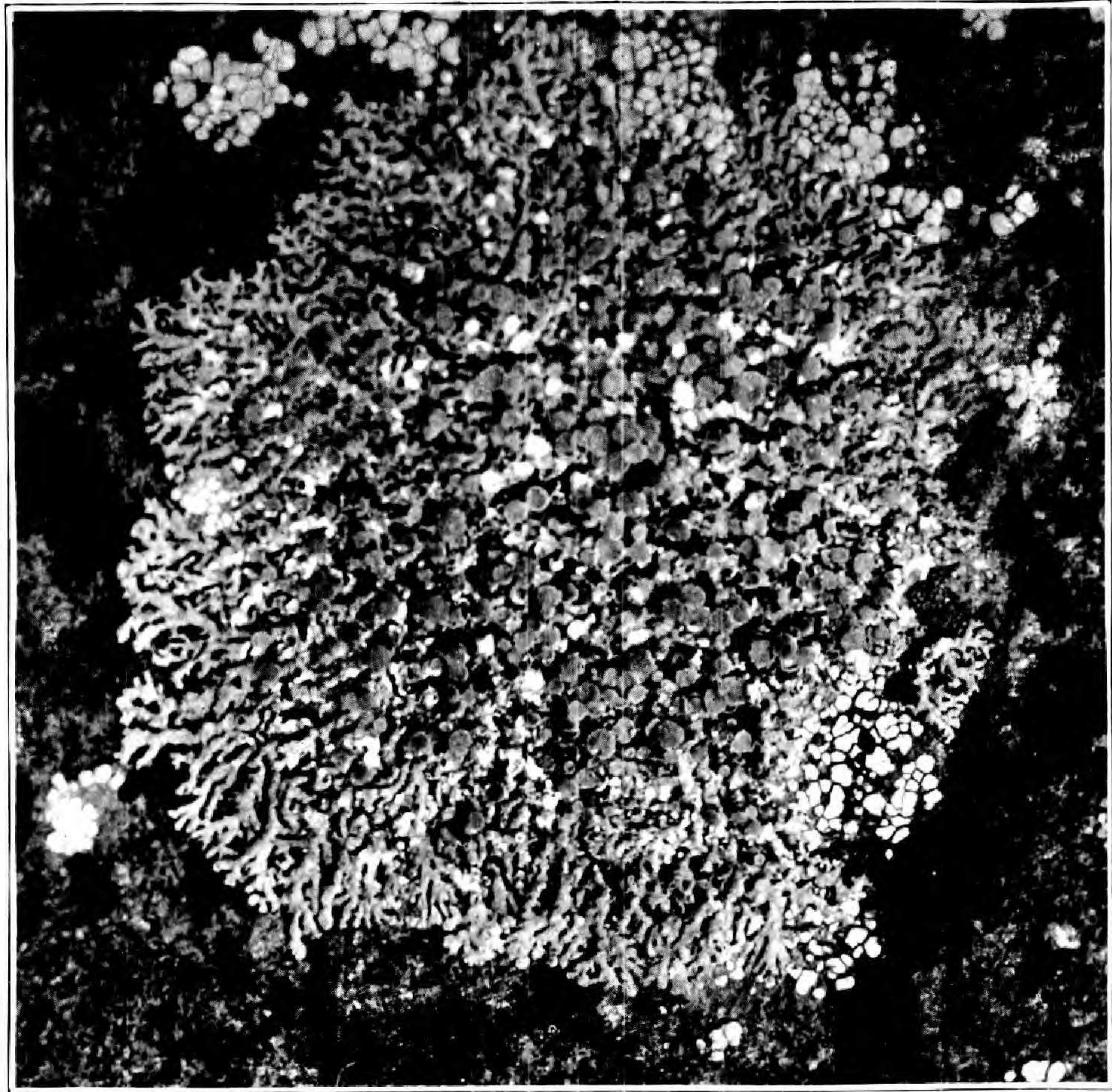
The apothecia are commonly rather small and sessile or adnate. The exciple is commonly thalloid, though a proper exciple is frequently more or less distinctly developed within this. Also the thalloid exciple may disappear, leaving the structure strictly biatoroid. Orange, yellow, and brown are common colors of the disk. The hymenium, hypothecium, and asci are much as in *Lecanora*. The paraphyses are also similar, but scarcely so slender. The spores are hyaline and usually of the polar 2-celled type, but in some of the species they are simply 2-celled and partly simple.

The more crustose and less lobed forms are sometimes separated as the genus *Callopisma*, but the transition is a gradual one, and it has seemed best not to divide the species. The transition in spore forms is also gradual, polar and nonpolar or 2-celled and simple spores quite commonly occurring in the same species and even in the same apothecium. As to spore characters, the present genus is plainly related to *Teloschistes*. As to thallus structure, the relation is as plainly with *Lecanora*, the structure being as a whole rather higher in the present genus.

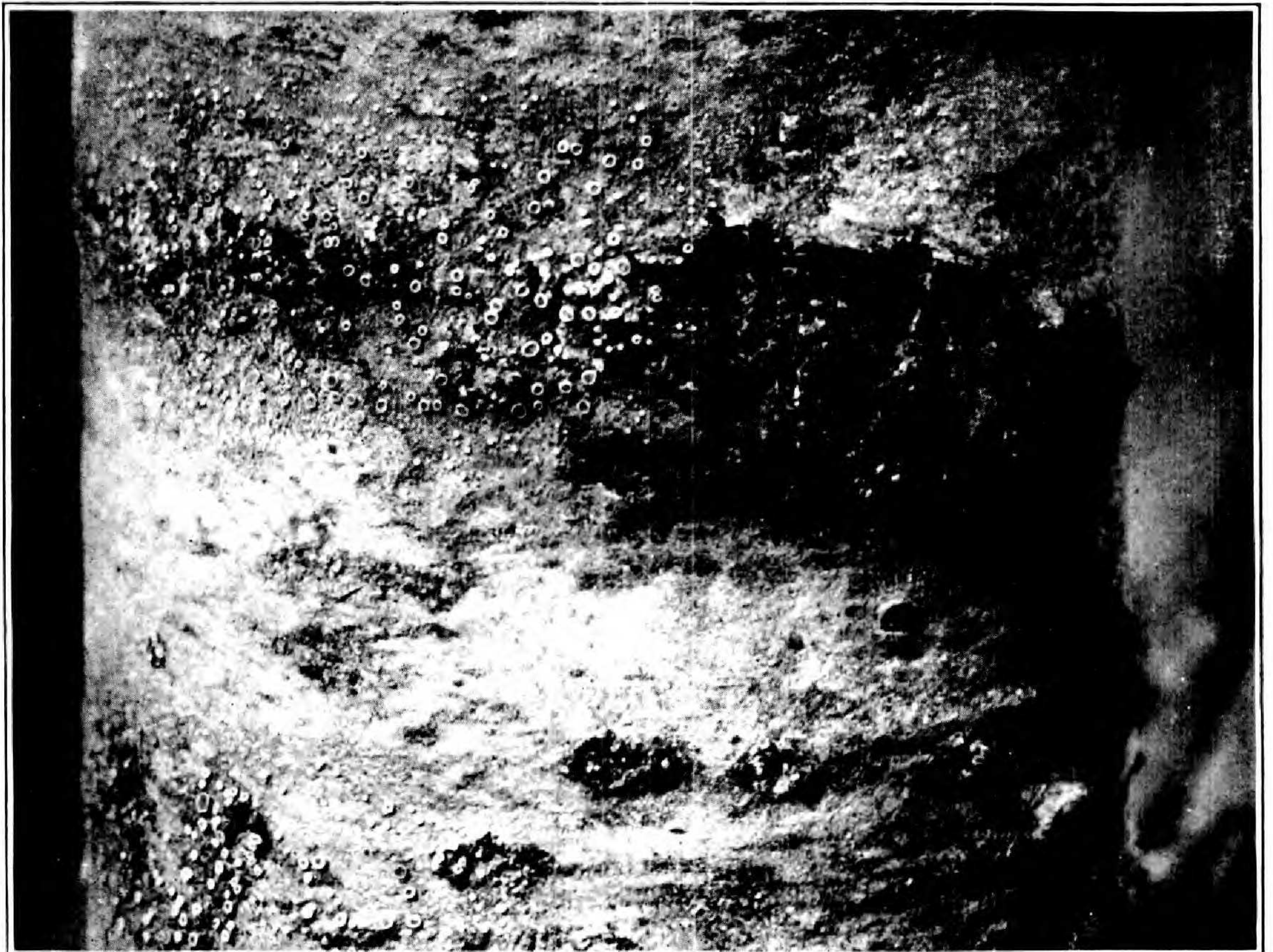
Fifteen species and subspecies occur in the State. On trees, rocks, and old wood. Type species *Placodium candelarium* (L.) Web. loc. cit.

KEY TO THE SPECIES.

- Section I. Thallus more or less lobed at the circumference.
- Thallus large, 25 to 70 mm. in diameter..... 1. *P. elegans*.
- Thallus smaller.
- Thallus only 8 to 45 mm. in diameter..... 2. *P. murorum*.
- Thallus still smaller..... 2a. *P. murorum* *mini-*
atum.
- Section II. Thallus not lobed at the circumference.
- On trees or on dead wood.
- On dead wood.
- Thallus dirty yellow or orange, of adnate squamules,
often forming an areolate crust..... 4. *P. microphyllum*.
- Thallus ashy or whitish.
- Thallus persistent and becoming thick and
verrucose..... 9. *P. ferrugineum*.
- Thallus thinner and tending to disappear.
- Disk yellowish orange; exciple disappear-
ing..... 8. *P. pyraccum*.
- Disk olivaceous and darker; exciple dis-
appearing..... 9a. *P. ferrugineum polli-*
ni.
- On trees.
- Thallus chinky, verrucose or areolate, grayish yel-
low or yellowish gray (also on rocks and old
wood)..... 6. *P. aurantiacum*.
- Thallus thinner and smoother, often chinky, ashy-
whitish or lead-gray.
- Exciple entire..... 7. *P. cerinum*.
- Exciple becoming subcrenulate or radiately
striate; disk pruinose..... 7a. *P. cerinum ulmorum*.
- On rocks.
- Thallus thick and often verrucose.
- Thallus grayish yellow or yellowish gray; disk
orange to saffron-colored..... 6. *P. aurantiacum*.
- Thallus sea-green to iron-gray; disk yellowish rust-
colored to blackish..... 7b. *P. cerinum sideritis*.
- Thallus thinner, granulose, chinky, or areolate.
- Thallus chinky-areolate or scattered-scaly, the
scales often lobed; usually dark orange..... 3. *P. cinnabarrinum*.
- Thallus granulose to areolate.
- Granules minute, lemon-colored, sometimes
compacted into a subareolate crust..... 5. *P. citrinum*.
- Granules larger and often crenate-lobed, bright
greenish yellow (also on old wood).
- Thallus persistent, the granules often com-
pacted into an areolate crust; exciple
granulate, crenate..... 10. *P. vitellinum*.
- Thallus of scattered granules, often disap-
pearing; exciple entire..... 10a. *P. vitellinum aurel-*
lum.



A. PLACODIUM ELEGANS (LINK) ACH.



B. PLACODIUM CERINUM (HOFFM.) HEPP.

1. *Placodium elegans* (Link.) Ach. Lich. Suec. 102, 255. 1798. PLATE 44, A.

Lichen elegans Link, Beitr. Naturgesch. 1: 37. 1794.

Thallus subfoliose, suborbicular, of medium size, 25 to 70 mm. in diameter, plainly lobed and stellate-radious in the best developed conditions, but closely adnate, the lobes free and becoming long, branched, wavy, convex above, sometimes subimbricate and often more or less lacunose; commonly orange above but varying toward yellowish or reddish, white below or darkening; upper cortex present and of moderate thickness, but not always distinctly cellular, the lower cortex much thinner; apothecia small or middle-sized, 0.5 to 2 mm. in diameter, sessile, the disk flat or concave, commonly orange-colored, the exciple entire or crenulate and of the same color as the thallus, not disappearing in ours at least; hypothecium commonly pale; hymenium pale below and yellowish or brownish above; paraphyses simple or branched, commonly enlarged and darker toward the apex; asci variously cylindric-clavate to broadly clavate; spores ovoid-ellipsoid, polar 2-celled, 9 to 18 μ long and 5 to 8.5 μ wide.

Generally distributed over the State. On rocks.

Throughout North America, but toward the south mostly confined to mountains. Known in all of the grand divisions.

EXPLANATION OF PLATE 44.—A, Plant of *Placodium elegans* on rocks, showing the closely adnate and marginally lobed thallus and the apothecia. B, Plant of *Placodium cerinum* on poplar, showing the small apothecia. A enlarged $1\frac{1}{4}$ diameters; B, 2 diameters.

2. *Placodium murorum* (Hoffm.) Ach. Lich. Suec. 101, 255. 1898.

Lichen murorum Hoffm. Enum. Lich. Icon. 63. pl. 9. f. 2. 1784.

Thallus when well developed orbicular, smaller than in the last, 8 to 45 mm. in diameter, more closely adnate than that of the last and to be regarded as crustose, though there is a poorly developed lower cortex over portions of the ventral surface, the upper cortex as in the last, the central portions commonly more or less verrucose, the margin passing into rather short but somewhat branched lobes, or the marginal lobing absent and the whole thallus composed of discrete verrucæ or squamules, usually bright yellow; apothecia small, 0.4 to 1 mm. in diameter, sessile, the disk flat or concave and orange red, the thalloid exciple thicker than in the last and more commonly crenulate, said to inclose a thin proper exciple; hypothecium commonly pale, hymenium pale below, yellowish above; paraphyses simple or branched, commonly enlarged and yellowish or brownish toward the apex; asci clavate; spores polar 2-celled, ovoid-ellipsoid, 10 to 15 μ long and 5 to 7 μ wide.

Collected at Thief River Falls, at Rainy Lake City, and in the Misquah Hills in the northern portion of the State; also once as far south as Granite Falls. On rocks other than calcareous.

In the northern United States and northward, and also as far south as southern California. Known also in South America, Europe, and Africa.

2a. *Placodium murorum miniatum* (Hoffm.) Nyl. Not. Sällsk. Faun. Flor. Fenn. 5: 136. 1861.

Lichen miniatus Hoffm. Enum. Lich. Icon. 62. 1784.

Thallus orange or reddish, smaller, 5 to 20 mm. in diameter; ours sterile.

Collected at Grand Portage. On rocks.

Elsewhere in North America in California. Known also in South America and Europe.

3. *Placodium cinnabarrinum* (Ach.) Anzi, Cat. Lich. Sondr. 43. 1860.

Lecanora cinnabarrina Ach. Lich. Univ. 402. 1810.

Thallus strictly crustose and closely adnate, more or less chinky or areolate, or the areoles scattered and forming scales, these commonly more or less crenately lobed, or the scales still retained in less scattered conditions and becoming somewhat imbricate; suborbicular and rather small, 5 to 30 mm. in diameter, or perhaps more often

irregular, then usually spread over larger areas, usually dark orange in color, an upper cortex of thin-walled cells present; apothecia small or minute, 0.2 to 0.7 mm. in diameter, adnate, often more or less angular, commonly numerous and obscuring the larger portion of the thallus, the disk orange and usually flat, the thalloid exciple commonly somewhat lighter-colored, entire; hypothecium commonly pale; hymenium pale below and yellowish or brownish above; paraphyses simple or rarely branched, slightly enlarged and colored toward the apex; asci clavate; spores ellipsoid, polar 2-celled, 7 to 12 μ long and 5 to 7 μ wide.

The plant is generally distributed over the State. On rocks.

Common throughout the United States. Occurring also in all of the grand divisions.

4. *Placodium microphyllum* Tuck. Syn. N. A. Lich. 1: 174. 1882.

Thallus composed of small and closely adnate squamules 0.5 to 1.5 mm. in diameter, these sometimes closely clustered toward the center into an areolate crust, dirty greenish-yellow and becoming dirty orange; marginal squamules often crenately lobed, often more or less obscured by minute yellow granules; a poorly developed upper cortex of thin-walled cells usually to be made out; apothecia small or minute, 0.3 to 0.5 mm. in diameter, adnate, the disk flat and dark orange, the thalloid exciple usually crenulate and inclosing an entire proper one; hypothecium pale; hymenium pale below and yellow brownish above; paraphyses simple or branched, commonly more or less enlarged and colored toward the apex; asci clavate; spores ellipsoid, polar 2-celled, 9 to 15 μ long and 5 to 7 μ wide.

Collected at Minneapolis. On old wood.

Generally distributed over the northern United States, and once found as far south as Texas. A North American plant, but by no means common in its territory.

5. *Placodium citrinum* (Hoffm.) Leight. Lich. Fl. Great Brit. 177. 1871.

Verrucaria citrina Hoffm. Deutsch. Fl. 2: 198. 1795.

Thallus crustose, composed of minute granules which are more or less scattered over the substratum or compacted into a subareolate crust, irregularly and often widely spread over the substratum, commonly lemon-colored; apothecia scarcely as large even as those of the last, adnate, the disk waxy-yellow or orange, commonly flat, the thalloid margin subgranulose, sometimes tending to disappear, said rarely to inclose a thin proper one; hypothecium pale; hymenium pale below and more or less yellowish brown above; paraphyses simple or branched, commonly somewhat enlarged and yellowish toward the apex; asci clavate to broadly clavate; spores ellipsoid or ovoid-ellipsoid, polar 2-celled, 8 to 14 μ long and 4.5 to 7 μ wide.

Generally distributed over the State. On rocks.

Widely distributed in the United States, but not yet known from the extreme South or West. Known in all of the grand divisions except Australia.

6. *Placodium aurantiacum* (Lightf.) Hepp, Spor. Flecht. Eur. pl. 45. f. 399. 1857.

Lichen aurantiacus Lightf. Fl. Scot. 2: 810. 1777.

Thallus crustose, smoothish and chinky or more commonly becoming verrucose and rugose or even areolate, lemon-colored, pale or darker yellow, yellowish gray, gray, or finally whitish, rarely more or less dissected with black lines, somewhat corticate above, more or less irregular and often widely spread over the substratum; apothecia small or becoming larger, 0.4 to 1 mm. in diameter, sessile, the disk commonly flat, orange to saffron-colored, the thalloid margin paler and usually becoming crenulate, rarely disappearing and leaving only a thin proper exciple (biatoroid); hypothecium pale; hymenium of same color below and yellowish or brownish above; paraphyses simple or quite frequently branched, usually somewhat enlarged and colored toward the apex; asci clavate; spores ellipsoid, polar 2-celled, 11 to 18 μ long and 6 to 9 μ wide.

Generally distributed over the State. On trees, old wood, and rocks.

Occurs throughout North America. Known in all of the grand divisions.

7. *Placodium cerinum* (Hoffm.) Hepp, Spor. Flecht. Eur. *pl.* 46. *f.* 405. 1857.

PLATE 44, B.

Patellaria cerina Hoffm. Descr. Pl. Crypt. 2: 32. *pl.* 33. *f.* 1. 1794.

Thallus crustose, suborbicular and of medium size, 15 to 55 mm. in diameter, or becoming irregular and more widely spread over the substratum, rarely disappearing, thin, smoothish and chinky or thicker and verrucose or sometimes becoming sub-areolate, ashy or varying toward whitish or more commonly toward lead-gray, an upper cortex scarcely distinguishable; apothecia small to nearly middle-sized, 0.3 to 1.2 mm. in diameter, sessile or possibly sometimes subsessile, the disk flat, waxy-yellow varying toward reddish or olivaceous-brown, the exciple thalloid and entire, of the same color as the thallus, whitish or sometimes of the color of the disk, sometimes becoming flexuous; hypothecium pale; hymenium pale beneath and yellowish or brownish above; paraphyses simple or branched, commonly more or less enlarged and colored toward the apex; asci clavate; spores ellipsoid, polar 2-celled, 10 to 18 μ long and 6 to 10 μ wide.

The plant is quite variable, and a large number of subspecies have been recognized. One of ours, however, seems to differ from all of these, and we venture to give it a name. Another form with evanescent thallus and closely clustered, rather flexuous, olivaceous-brown apothecia was collected on old pine wood at Red Lake. Finally, one of the two subspecies admitted by Tuckerman, it seems to us, must be separated.

Generally distributed over the State. On trees and rarely on old wood.

Found throughout North America. Known also in all of the grand divisions.

EXPLANATION OF PLATE 44.—See page 213.

7a. *Placodium cerinum ulmorum* Fink, Proc. Iowa Acad. Sci. 11: 143. 1904.

Thallus of moderate thickness, granulose-verrucose, ashy or sea-green, irregularly spread over the substratum usually in small patches; apothecia of the usual size, the disk dull waxy yellow, roughened and more or less pruinose, the exciple prominent, ashy-whitish, entire or more commonly subcrenulate or radiately striate.

Generally distributed over the southern half of the State. On elms and rarely on other trees, especially oaks.

The subspecies is common in Iowa and has been collected in Kansas by E. Bartholomew. The Kansas material was on red cedar bark.

7b. *Placodium cerinum sideritis* Tuck. Syn. N. A. Lich. 1: 175. 1882.

Thallus thickened, composed of contiguous, scaly, and frequently convex verrucæ or areoles, of the same color as the last (said by Tuckerman to be iron-gray); apothecia adnate or rarely immersed, rather smaller, the disk nonpruinose, yellowish rust-colored, or in ours becoming darker and even black, the exciple of the color of the thallus and sometimes disappearing; spores rather smaller.

Doctor Zahlbruckner considers part of ours a new species, but gives no name.

Considered by Tuckerman as a strictly North American form, and the differences as to thallus and the adnate or immersed apothecia would seem to indicate a new species rather than a subspecies of the above species. Some other disposition of all or part of our material will doubtless need to be made.

Generally distributed over the State. On rocks other than calcareous.

A strictly North American plant. Elsewhere known in New England, Virginia, Illinois, and Iowa.

8. *Placodium pyraceum* (Ach.) Fink.

Parmelia cerina pyracea Ach. Meth. Lich. 176. 1803.

Thallus very thin and ashy-whitish, smooth or granulate-scurfy, evanescent; apothecia small or minute, 0.2 to 0.6 mm. in diameter, sessile or rarely adnate, frequently numerous, clustered, angulate and obscuring the thallus, the disk flat or convex, yellowish-orange, the thalloid exciple thin and yellowish or whitish, evanescent, and the apothecia, as commonly seen, biatoroid, with thin proper exciple;

hypothecium pale; hymenium pale below and yellowish above; paraphyses simple or branched, frequently enlarged and slightly colored toward the apex; asci clavate; spores polar 2-celled, ellipsoid or ovoid-ellipsoid, 10 to 16 μ long and 5 to 9 μ wide, the number of nonpolar spores larger than in most of the species.

The species seems clear enough as it occurs on old wood, but transitional forms of the last certainly occur on trees.

Generally distributed over the State. On old wood.

Found throughout the northern United States and northward. Also in southern California. Known in all of the grand divisions except Africa.

Placodium cerinum pyracea of the preliminary reports.

9. *Placodium ferrugineum* (Huds.) Hepp, Spor. Flecht. Eur. pl. 45. f. 400. 1857.

Lichen ferrugineus Huds. Fl. Angl. ed. 2. 526. 1778.

Thallus crustose and commonly thin, rather smooth and chinky or becoming rugose and verrucose, ashy or whitish, usually more or less irregular and variously disposed upon the substratum, with a thin layer above the algal cells, but scarcely to be regarded as corticate, the whole thallus sometimes becoming scattered and tending to disappear; apothecia small to almost middle-sized, 0.3 to 1.3 mm. in diameter, the thalloid exciple evanescent and the structure early becoming biatoroid, sessile, the disk flat, rust-colored or blackening, frequently subpruinose; hypothecium brown or brownish; hymenium pale below and brownish above; paraphyses simple or branched, commonly enlarged and brownish toward the apex; spores ellipsoid, polar 2-celled, 11 to 20 μ long and 6 to 10 μ wide.

Collected at such remotely separate localities as Mankato, Bemidji, Red Lake, and Rainy Lake City. On dead coniferous wood. Easily passed over for a *Biatora* and no doubt generally diffused throughout the State.

Generally distributed over North America. Found also in Europe and Africa.

9a. *Placodium ferrugineum pollinii* (Mass.) Tuck. Syn. N. A. Lich. 1: 177. 1882.

Blastenia pollinii Mass. Flora 35: 575. 1852.

Thallus thinner, whitish, and tending to disappear; apothecia biatoroid, becoming more or less convex, the proper exciple tending to disappear, the disk olivaceous and blackening.

Distribution in the State quite as that of the species as is also the habitat.

Elsewhere in North America in New England, Maryland, Illinois, Iowa, and Nebraska. Known also in Europe.

10. *Placodium vitellinum* (Hoffm.) Hepp, Spor. Flecht. Eur. pl. 44. f. 391. 1857.

Patellaria vitellina Hoffm. Descr. Pl. Crypt. 2: 5. pl. 26. f. 2. 1794.

Thallus crustose-granulate, composed of small rounded or finally squamulose and crenate-lobed granules, which may be scattered or grouped into areole-like clusters, bright greenish-yellow, forming a more or less broken or rarely continuous layer, usually irregular and more or less spread over the substratum, with some suggestion of an upper cellular cortex at least over portions of some thalli; apothecia rather small, 0.3 to 1.3 mm. in diameter, sessile, the disk commonly flat, tawny-yellow, becoming olivaceous, the exciple thalloid and granulate-crenate; hypothecium pale; hymenium pale below and yellowish above; paraphyses simple or branched, commonly enlarged and yellowish toward the apex; spores commonly 12 to 32 in each ascus (rarely only 8), ellipsoid, 2-celled and simple, 8 to 16 μ long and 4 to 7 μ wide.

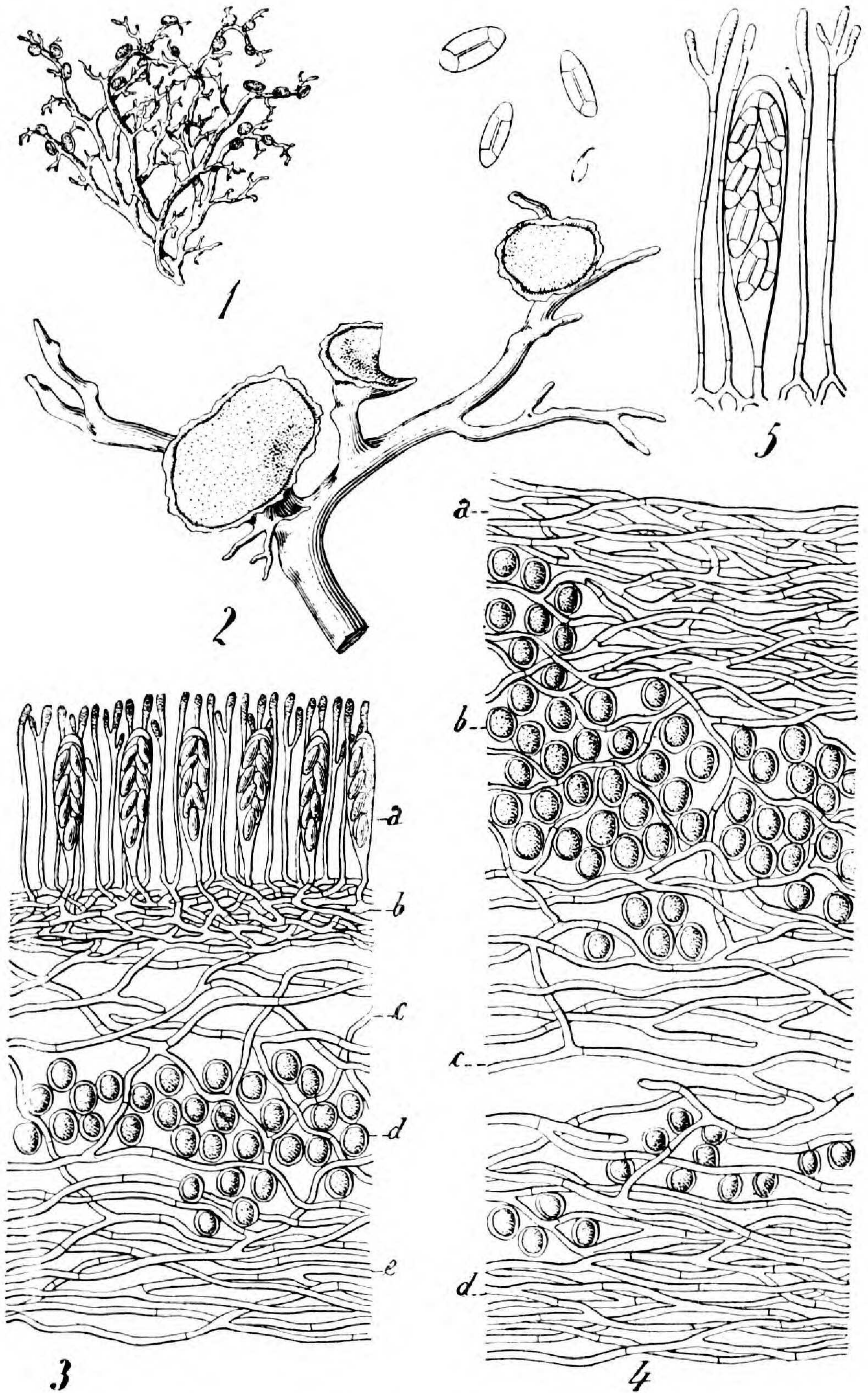
Generally distributed over the State. On rocks and old wood.

Found throughout North America. Known in all of the grand divisions.

10a. *Placodium vitellinum aurellum* (Hoffm.) Tuck. Syn. N. A. Lich. 1: 180. 1882.

Patellaria vitellina aurella Hoffm. Deutsch. Fl. 2: 197. 1795.

Thallus scattered and disappearing; apothecia smaller with entire exciple; spores rather more commonly simple.



TELOSCHISTES CHRYSOPHTHALMUS (L.) TH. FR.

Distribution in the State the same as that of the species. On rocks.

Occurs in Iowa, Missouri, Kansas, California, and eastern British America. Known also in Europe.

TELOSCHISTES Norm. *Nyt. Mag. Naturv.* 7: 228. *pl. 1. f. 4 a-g.* 1853.

PLATE 45.

The thallus is usually foliose or subfruticose, a single species rising to a fairly good fruticose condition. In the foliose species the thallus shows a well developed cellular cortex above and below, and the space within is traversed by the loosely entwined medullary hyphæ. The algal layer lies among the medullary hyphæ just below the upper cortex, or in small thalli, especially in *Teloschistes concolor*, the algal cells may fill nearly all of the space between the medullary hyphæ. In the more or less fruticose thallus of *Teloschistes chrysophthalmus* there is a marked tendency toward a radial arrangement of tissues in the erect lobes of the thallus. In these the algal layer is frequently developed on both sides of the compressed lobes inside of the pseudocortex, inclosing more or less medullary tissue. Rhizoids and cilia are more or less characteristic of all the species. The thallus lobes in the foliose species are usually short, but somewhat dissected, and commonly show a tendency to ascend at the margins. The prevailing color is yellow or orange, which manifests itself most commonly in the disks of the apothecia. The upper surface of the thallus usually shows the characteristic color also, but often varies toward gray or sea-green. The lower surface usually shows these paler colors with a tendency toward pale yellow.

The apothecia are found more or less commonly in all of the species and may be terminal, marginal, or upon the upper surface of the thallus. The disk is commonly yellow or orange, and the margin is frequently ciliate. The hypothecium and hymenium are generally pale or slightly colored. The spores are of the polar 2-celled type, though this grades into an ordinary 2-celled condition even in a given species, while in one species admitted to the genus the numerous spores are constantly simple or of the ordinary 2-celled type. Aside from the single species, there are 8 spores in each ascus.

In structure of the thallus the genus is close to *Physcia*, while in coloration and more especially in spore characters the relation with *Placodium* is close. *Teloschistes* is no doubt more closely related to the latter genus.

Five species and subspecies occur in the State. On trees, old wood, and rocks.

Type species *Teloschistes flavicans* (Sw.) Norm. loc. cit.

EXPLANATION OF PLATE 45.—Fig. 1, the plant, showing the branching fruticose thallus and the apothecia. Fig. 2, a portion of thallus and three apothecia. Fig. 3, a section of an apothecium and the thallus below; *a*, the hymenium; *b*, the hypothecium; *c*, the fungal hyphæ; *d*, the algal cells; *e*, the pseudocortex of entangled hyphæ. Fig. 4, a longitudinal section of the thallus; *a* and *d*, the pseudocortex of hyphæ; *b*, the better developed algal layer of the upper side of the ascending branch; *c*, the medullary layer. Fig. 5, paraphyses and an ascus. Fig. 6, free polar 2-celled spores. Fig. 1, natural size; fig. 2, enlarged about 8 diameters; figs. 3, 4, enlarged 400 diameters; figs. 5, 6, enlarged 650 diameters. From Schneider.

KEY TO THE SPECIES.

- Thallus subfruticose, erect, spreading, or subpendent. 1. *T. chrysophthalmus*.
 Thallus foliose.
 Thallus lobes reduced to granulose-margined squamules,
 or the whole thallus reduced to a greenish-yellow,
 powdery crust. 4a. *T. concolor effusus*.
 Thallus lobes well developed.
 Margins of the lobes or the whole lobes ascendant;
 margins isidioid-granulose. 3. *T. lychneus*.

Margins of the lobes scarcely raised.

- Thallus commonly yellow or orange; spores
eight in each ascus..... 2. *T. polycarpus*.
Thallus greenish yellow or rarely yellow;
spores many in each ascus..... 4. *T. concolor*.

1. *Teloschistes chrysophthalmus* (L.) Th. Fr. Gen. Het. Eur. 51. 1861.

PLATE 45.

Lichen chrysophthalmus L. Mant. Pl. 2: 311. 1771.

Thallus tufted, subfruticose, erect, spreading, or showing a pendent tendency, quite rigid, fibrillose, the long lobes compressed and freely branching dichotomously, the fibrils few or more numerous toward the apices of the lobes, showing a pseudo-cortex; yellow to sea-green toward the top and paler toward the bottom and on the lower side; 4 to 15 mm. long, though plants from outside the State are frequently longer; apothecia small or medium, 1 to 5 mm. in diameter, terminal or subterminal, the margin more or less ciliate, or devoid of cilia in ours; the disk orange, concave or flat; hypothecium pale; hymenium pale below and pale or pale yellowish above; paraphyses conspicuously jointed, branched toward the apex, the apices of the branches pale or yellowish and often somewhat thickened; asci cylindrico-clavate or ovate-cylindrical; spores ellipsoid, polar 2-celled or occasionally some of them not polar, 10 to 16 μ long and 5 to 8 μ wide.

Infrequent, but known to exist in all parts of the State except the northeastern portion. On trees or old wood.

Occurring in some form in all parts of North America. Also distributed throughout all the grand divisions.

2. *Teloschistes polycarpus* (Hoffm.) Tuck. Syn. N. A. Lich. 1: 50. 1882.

PLATE 46, A.

Lobaria polycarpa Hoffm. Deutsch. Fl. 2: 159. 1795.

Thallus foliose, 6 to 20 mm. in diameter, prostrate, the margins scarcely raised, circular or irregular, the lobes small, narrow, freely divided or occasionally much reduced, imbricated or often scattered, the lower side more or less furnished with pale rhizoids and marginal pale or yellow fibrils, frequently almost wholly concealed by the commonly numerous apothecia, yellow or orange above or varying toward brownish or grayish, pale beneath; apothecia orange or at least darker than the thallus and having a paler entire or crenulate margin, rather small and commonly very numerous, concave or flat, commonly subpedicellate, rarely more or less fibrillose below, 1 to 4 or rarely 5 mm. in diameter; hypothecium pale; hymenium pale below and pale or yellowish above; paraphyses conspicuously jointed and usually branched toward the apex, the apices of the branches pale or yellowish and enlarged; asci ovate-clavate or cylindrico-clavate; spores ellipsoid, polar 2-celled or occasionally partly nonpolar, 12 to 18 μ long and 5 to 8 μ wide.

Our most common species, and found in all parts of the State. On trees, old wood, and very rarely on rocks.

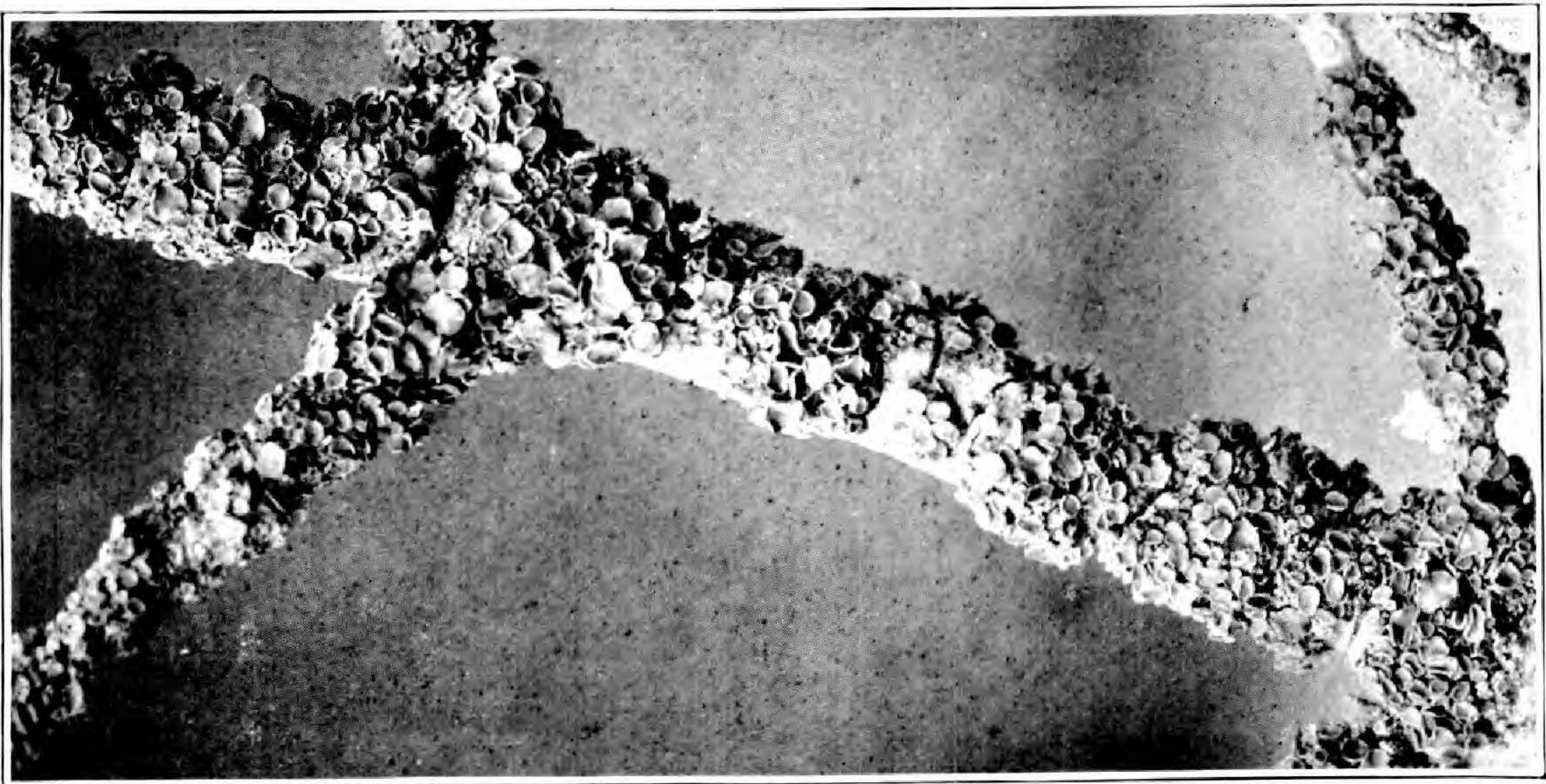
Occurs in all parts of North America. Also distributed throughout the grand divisions.

EXPLANATION OF PLATE 46.—A, Plant of *Teloschistes polycarpus* on a dead branch, showing the numerous apothecia characteristic of the species. B, Plant of *Rinodina sophodes* on a tree trunk, showing the crustose thallus and the apothecia. A and B enlarged $1\frac{1}{2}$ diameters.

3. *Teloschistes lychneus* (Ach.) Tuck. Syn. N. A. Lich. 1: 50. 1882.

Parmelia candelabra lychnea Ach. Meth. Lich. 187. 1803.

Thallus foliose, rather larger than in the last, 12 to 35 mm. in diameter, ascending or subprostrate with ascendant margins, compact and the lobes more or less imbricate, these in ours larger, wider, and rather less divided than in the last, the margins isidioid-granulate, the lower side more or less furnished with pale rhizoids and



A. *TELOSCHISTES POLYCARPUS* (HOFFM.) TUCK.



B. *RINODINA SOPHODES* (ACH.) KOERB.

marginal pale or yellow fibrils; yellow or orange above and pale below; apothecia rather rare, of the same size as in the last and of the same color or commonly brighter and occasionally even orange-red, the margin entire, crenulate or isidioid-granulate, commonly subpedicellate, and sometimes fibrillose below; hypothecium pale or slightly darkened; hymenium pale or yellowish-tinged, or yellowish above only; paraphyses conspicuously jointed and commonly branched toward the apex, the tips pale or yellowish and usually enlarged; asci ovate-cylindrical or cylindrico-clavate; spores oblong to ellipsoid, the mature ones, as in the two species above, being at least very largely polar 2-celled, 12 to 16 μ long and 5.5 to 7.5 μ wide.

The plant as it occurs in Minnesota is a large form of the species, our description varying somewhat from that of Tuckerman, especially as to the size of the plant and form of the lobes. Ours is nearer than usual to *Teloschistes parietinus*, but it never need be confused either with this or the last species above.

As widely distributed in the State as the last, but rather rare. On trees and rarely on rocks.

Widely distributed in North America as also in northern Euro-Asia. Known also in South America.

4. *Teloschistes concolor* (Dicks.) Tuck. Syn. N. A. Lich. 1: 51. 1882.

Lichen concolor Dicks. Pl. Crypt. Brit. 3: 18. pl. 9. f. 8. 1793.

Thallus foliose, smaller than in the above foliose species, suborbicular or the lobes scattered, when not scattered 4 to 25 mm. in diameter, prostrate or the margins sometimes slightly ascending, compact with lobes more or less imbricate or even passing into a continuous roughened crust toward the center, or the lobes more or less scattered and usually very narrow and irregularly much divided at least toward the circumference, the margins frequently finely granulate, the lower side bearing numerous pale rhizoids and pale marginal fibrils; greenish yellow or rarely yellow above and pale beneath; apothecia of same color as the thallus or more commonly a brighter yellow or rarely brownish, the margin entire or crenulate, sessile, and sometimes fibrillose below, 0.5 to 1.5 mm. in diameter; hypothecium pale or slightly darkened; hymenium pale or yellowish above; paraphyses plainly jointed, simple or rarely branched at the tips, these pale and enlarged; asci clavate, large; spores simple or 2-celled (not polar), many in each ascus, oblong, 5 to 11 μ long and 3 to 5 μ wide.

Distributed over all of the State except the northeastern region covered by the fourth report of the preliminary survey. On trees and old wood.

The plant is widely distributed in North America and is also known in Europe, Asia, and South America.

4a. *Teloschistes concolor effusus* Tuck. Syn. N. A. Lich. 1: 52. 1882.

Thallus lobes reduced to squamules, these granulose, at least at the margins, and passing sometimes into a powdery crust; in ours the squamules frequently scattered.

A form has also been placed here which has the apothecial characters of the present subspecies, but has the thallus reduced to scattered granules.

The subspecies has been reported from several localities in the northwestern portion of the State and from Mankato, well to the south. However, some of our specimens are hardly the subspecies. On trees.

Tuckerman gives the subspecies the same North American distribution as the species. Apparently not noted elsewhere.

Family PHYSCIACEAE.

If we take into account the three elements—thallus structure, the development of the apothecia, and the spore characters, we have plainly enough in the Physciaceae the highest family of the Discocarpaceae. And this becomes more apparent with our disposition of *Urceolaria* in the present family.

It is by no means plain that the present family is highest as regards thallus structure or development of the apothecia, but it is when we consider these elements in connection with the spore characters that the position of the family becomes apparent. We have the muriform spore in the Gyrophoraceae, the Lecideaceae, and the Graphidaceae as well as here, but always in connection with lower types of structure of thallus or apothecia, or both.

The relationships of the family with the Parmeliaceae and the Teloschistaceae have been given in the descriptions of those families, and it need only be added here that in admitting *Urceolaria* to the present family we have established a somewhat close relationship with the Gyalectaceae, through *Urceolaria* and *Conotrema*.

The first two genera of the family are well represented in our flora, but our members of the family as a whole are not very numerous. The thallus structure shows about the same amount of variation as is found in the last family, and the relationship of the apothecia to the thallus is about the same as in the Parmeliaceae. But the spores are always brown and vary from 2-celled to muriform conditions.

RINODINA Ach.; S. F. Gray, Nat. Arr. Brit. Pl. 1: 448. 1821.

The thallus is crustose, though in a few species herein admitted to the genus there is more or less of lobing at the circumference. The structure is closely adnate, usually areolate, and is attached to the substratum by commonly dark hyphal rhizoids. In the lobed forms, there is more or less of an upper pseudocortex of hyphæ, but in the lower more strictly crustose species, the cortex is absent, or rather represented by a bending and branching of the hyphæ near the upper surface, to form the poorly developed protective layer so common in crustose thalli. The algal symbionts are commonly *Cystococcus*, though they vary considerably in size in the different species, and in some species having larger and more irregular algæ, *Pleurococcus* may replace the usual *Cystococcus*. The common colors of the thalli are sea-green, ashy, straw-color, and yellowish.

The apothecia are commonly small or minute, and may be immersed, adnate, or sessile. Indeed, all of the above dispositions of apothecia may occur in a single species. The exciple is thalloid, but in a majority of the species this structure may disappear entirely. The disk is commonly flat and its color usually black or brownish black. The hypothecium is commonly pale, though sometimes brownish. The paraphyses are simple or rather rarely branched. The spores are brown and 2-celled.

The present genus is doubtless to be regarded as intermediate between *Physcia* and *Buellia*, lower than the former and on the whole higher than the latter. The thalli of the best developed *Rinodinas* seem quite as high as those of the lowest *Physcias*, while some of the lower members of the present genus show thalli scarcely better developed than those of some of the *Buellias*. The thalli and the apothecia of the *Rinodinas* also resemble those of *Lecanoras* and *Placodiums*, but the spores indicate a much closer relationship with the two genera named above. Finally, the tendency of the thalloid exciple to disappear looks toward *Buellia*. Possibly our *Rinodina oreina* should be excluded from the genus, but the thallus is after all essentially crustose.

Ten forms occur in the State. On trees and rocks.

Type species *Rinodina atra* (Huds.) S. F. Gray, loc. cit. But this is *Lecanora atra*, and the generic name *Rinodina* will doubtless have to be abandoned eventually.

KEY TO THE SPECIES.

Confined to rocks.

Thallus blackish, of flat or concave areoles..... 6. *R. nigra*.

Thallus lighter-colored.

Thallus granulose, becoming chinky, scurfy or sub-areolate, whitish, sea-green or brownish..... 4. *R. bischoffii*.

Thallus never granulose, but more or less chinky-areolate.

Thallus with plainly lobed and often black-fringed margin; greenish straw-colored or yellowish. 1. *R. oreina*.

Thallus chinky or scaly-areolate, not lobed; sea-green to olivaceous. 5. *R. lecanorina*.

Not confined to rocks.

On trees or dead wood.

Thallus and exciple thin and disappearing. 3d. *R. sophodes exigua*.

Thallus and exciple thicker and more persistent.

Spores 20 to 35 μ long. 2. *R. ascociscana*.

Spores 14 to 22 μ long. 3b. *R. sophodes tephrae*.

Habitat various.

Thallus coarse, verrucose and sometimes lobulate, whitish. 3c. *R. sophodes confragosa*.

Thallus finer, granulose or granulose-areolate.

Thallus of minute granules, sometimes forming a subareolate crust; ashy to olive-brown. 3. *R. sophodes*.

Thallus granulose-areolate, or scattered subsquamulose; ashy to sea-green. 3a. *R. sophodes atrocinerea*.

1. *Rinodina oreina* (Ach.) Mass. Ric. Lich. 16. *f.* 24. 1852.

Lecanora straminea oreina Ach. Lich. Univ. 433. 1810.

Thallus verrucose-areolate, except the margin which passes into distinct and more or less lobed squamules or somewhat elongated, branched, and usually densely crowded lobes, the areoles or verrucæ about 0.5 to 1 mm. across, greenish straw-colored or yellowish, the marginal lobes or squamules, at least, showing a thin upper pseudo-cortex of mostly vertical hyphæ and the algal and medullary layers somewhat differentiated, suborbicular with the marginal lobes or squamules well represented, or becoming irregular and more widely spread over the substratum with the lobation tending to disappear, the more regular forms commonly 12 to 55 mm. across, the margin commonly more or less black-edged; apothecia small or minute, 0.2 to 0.75 mm. in diameter, immersed or becoming adnate, or even sessile, the disk black and commonly flat, the thalloid exciple obtuse and entire, rarely disappearing, the apothecia then somewhat lecideoid; hypothecium pale; hymenium commonly pale beneath and brown or brownish above; paraphyses simple or branched, commonly thickened and brownish toward the apex; asci clavate; spores short-ellipsoid, 9 to 12 μ long and 4.5 to 7.5 μ wide.

Generally distributed over the State. On rocks other than calcareous.

Throughout North America, except the most southern States and southward. Found also in Europe.

2. *Rinodina ascociscana* Tuck. Gen. Lich. 124. 1872.

Psoroma ascociscana Tuck. Amer. Journ. Sci. 25: 424. 1858.

Thallus a suborbicular, chinky crust, which becomes more or less concentrically wrinkled and passes into scaly-areolate conditions, scarcely corticate, sea-green and passing into a pale cinnamon-brown; apothecia small to middle-sized, 0.6 to 1.5 mm. or more in diameter, sessile, the disk flat or slightly convex, from pale brown to black, the thalloid exciple persistent, entire or crenate; hypothecium pale; hymenium of same color below and brownish above; paraphyses simple or rarely branched, commonly enlarged and brownish toward the apex; asci clavate; spores 20 to 35 μ long and 10 to 16 μ wide.

Our plant is scarcely so well marked as Tuckerman's and may yet prove to be an unusually well developed form of the next species below.

Collected at Gunflint and at Tofte. On trees.

A North American plant found elsewhere in New England, in Illinois, and in arctic America.

3. *Rinodina sophodes* (Ach.) Koerb. Syst. Lich. 122. 1855. PLATE 46, B.
Lichen sophodes Ach. Lich. Suec. 67. 1798.

Thallus composed of minute granules, these running together to form a thin, continuous, or more or less scattered, granulate and roughened or subareolate crust, ashy and passing into olivaceous-brown, irregularly and often widely spread over the substratum; apothecia small or minute, 0.3 to 0.8 mm. in diameter, adnate, the disk flat or convex and brown to blackish, the thalloid margin entire or subentire and inclosing a thin and more persistent proper exciple, the thalloid one frequently tending to disappear; hypothecium pale to brownish; hymenium pale below and commonly brownish above; paraphyses simple or rarely branched toward the commonly enlarged and brownish apex; asci clavate; spores oblong-ellipsoid, 14 to 22 μ long and 6 to 12 μ wide.

Found throughout the State. On trees, old wood, and rocks.

Distributed throughout North America. Known also in all of the grand divisions.

EXPLANATION OF PLATE 46.—See p. 218.

3a. *Rinodina sophodes atrocinerea* (Dicks.) Tuck. Syn. N. A. Lich. 1: 207. 1882.
Lichen atrocinereus Dicks. Pl. Crypt. Brit. 3. 14. *pl. 14. f. 9.* 1793.

Thallus granulose areolate or subsquamose and the areoles or squamules somewhat scattered; apothecia scarcely ever minute, the thalloid exciple often disappearing; spores of the usual size.

Collected at Bemidji. On cedars in swamps. Said to be a rock form, but ours seems to belong here.

Definitely reported, as far as known, only from California and Ontario, but doubtless widely distributed in North America. Known also in Europe.

3b. *Rinodina sophodes tephraispis* Tuck. Syn. N. A. Lich. 1: 208. 1882.

Rinodina tephraispis Tuck. Amer. Journ. Sci. 25: 425. 1858.

Thallus thickened and roughened, composed of crenulate, or more often verrucose-irregular and crowded areoles, brownish-ashy; apothecia finally middle-sized and prominent, 0.6 to 2 mm. in diameter, becoming convex, hemispherical, and variously irregular, the thalloid exciple said to be persistent, but disappearing in ours.

Collected at Pipestone, at Warroad, on Flag Island in Lake of the Woods, and at Tower, thus apparently widely distributed in the State. On rocks other than calcareous.

Definitely recorded elsewhere in North America in only one or two localities, but doubtless more widely distributed and overlooked or referred elsewhere. A North American subspecies.

3c. *Rinodina sophodes confragosa* (Ach.) Tuck. Gen. Lich. 123. 1872.

Parmelia confragosa Ach. Meth. Lich. Suppl. 33. 1803.

Thallus rather coarse, commonly verrucose and sometimes sublobate, whitish; apothecia becoming middle-sized; spores in ours possibly surpassing 30 μ in length.

This does not agree very closely with the published descriptions, and must be regarded as a provisional disposition.

Collected at Snowbank Lake. On old wood, though more commonly a rock lichen.

Elsewhere in North America, definitely reported from Illinois, California, Ontario, and Vancouver Island. Known also in Europe, Asia, and Africa.

3d. *Rinodina sophodes exigua* (Ach.) Tuck. Syn. N. A. Lich. 1: 208. 1882.

Lichen exiguus Ach. Lich. Suec. 69. 1798.

Thallus small, sometimes becoming scurfy or disappearing; apothecia minute or smaller than usual, the disk becoming convex, the thalloid exciple becoming crenulate and disappearing; spores rather small, frequently more than 8 in each ascus, in ours sometimes reaching 30.

Generally distributed over the State. On trees and old wood.

Found in all portions of North America. Known also in all of the grand divisions except Asia.

4. *Rinodina bischoffii* Koerb. Par. Lich. 75. 1865.

Thallus composed of small granules, these running together to form a usually thin, more or less chinky, scurfy, or rarely subareolate crust, this either scattered or continuous and spread irregularly over rather small areas of the substratum, in some of ours becoming thicker and in others tending to disappear; from whitish to sea-green or brownish; apothecia small or subminute, 0.4 to 0.8 mm. in diameter, sessile, the disk dark brown and becoming blackish, flat or somewhat convex, the thalloid exciple entire and persistent, but rarely blackening, a thin proper exciple within the thalloid one; hypothecium commonly pale; hymenium pale below and brownish above; paraphyses somewhat coherent, simple or rarely branched toward the commonly enlarged and brownish apex; asci clavate or ventricose-clavate; spores ovoid-ellipsoid, 15 to 20 μ long and 8 to 13 μ wide, the wide interval between the two cells indicated usually by a dark band.

Doctor Koerber recognized two subspecies, *protuberans* and *immersa*, the former with distinct thallus and elevated-sessile apothecia, the other with both thallus and apothecia more or less immersed in the substratum. Ours corresponds to the former.

Collected at Mankato, at Morton, and in the Leaf Hills. On calcareous rocks and pebbles. No doubt occurring on such substrata elsewhere in the State.

Elsewhere in North America in Illinois, Iowa, Kansas, Texas, and the Rocky Mountains. Known also in Europe and Africa.

5. *Rinodina lecanorina* Mass. Sched. Crit. Lich. Exsicc. 48. 1855.

Mischoblastia lecanorina Mass. Ric. Lich. 41. f. 70. 1852.

Thallus composed of flat or somewhat convex areoles, these small to middle, sized, 0.3 to 1.5 mm. across, and usually widely spread over the substratum as a continuous or more or less broken crust; sea-green varying toward olivaceous; apothecia small or minute, 0.3 to 0.8 mm. in diameter, immersed one or more in each areole, or in ours becoming more or less superficial upon the rather poorly developed thallus and showing a thalloid exciple, which finally disappears, the disk flat or convex, dark brown or black in color, usually rounded but sometimes more or less irregular; hypothecium pale; hymenium pale below and brownish above; paraphyses simple or branched; asci clavate; spores oblong or oblong-ellipsoid, 15 to 21 μ long and 9 to 10 μ wide.

Reported from Mankato, Oak Island, Koochiching, and Rainy Lake City. On granitic rocks. Our plants differ from European material in the poorer thallus development and more superficial apothecia. Doctor Zahlbruckner has named, but as yet not described, *Rinodina ioensis*, from Fayette, Iowa, which some of our material externally quite as much resembles as it does *R. lecanorina*.

Not known elsewhere in North America. Found in Europe.

6. *Rinodina nigra* Fink, Minn. Bot. Stud. 2: 695. 1901.

Thallus of moderate thickness, composed of flat or somewhat concave areoles, each areole 0.5 to 1 mm. in diameter, without cortex, dark slate-color, commonly irregular and spread as a continuous or more or less broken layer over larger or smaller areas